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Effects of Reverse Walking with And Without Whole Body Vibration on Postural Balance and Quality of Life in Children with Cerebral Palsy

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Abstract

Background: Cerebral palsy is the most common cause of spasticity and physical disability in children and spasticity is one of the commonest problems in those with neurological disease. It produces non-progressive brain abnormalities, resulting in mobility difficulties and influencing sensation, perception, cognition, behavior, and communication. Spasticity, dyskinesia, and hyperreflexia impair motor control of walking, reaching, and object gripping precision

Objective: To determine the effects of reverse walking with and without Whole-body vibration on postural balance in children with cerebral palsy.

Methods: In this randomized clinical trial, 22 subjects with Age 6–12 years from both genders and confirm diagnosis of cerebral palsy having GMFCS level I & II were included. The study was conducted in Hussain Memorial Hospital Lahore over the duration of 6 months. The subjects were divided into two groups; Group A was treated with (Whole Body Vibration + Reverse Walking) and Group B was treated with Reverse Walking alone. They received treatment session for 3 days / week for 3 months. Outcomes were measured at baseline and at 12th week. Data was analyzed by SPSS version 26.

Results: It shows statistically significant results as p= <.001. So, we reject the null hypothesis. Indicates that the mean difference in group A is more than mean difference in group B which shows that the whole-body vibration + reverse walking was more effective than reverse walking alone in improving postural balance, Reach and quality of life in cerebral palsy.

Conclusions: Current study concluded that reverse walking with and without whole body vibration were effective in improving postural balance, reach and quality of life in cerebral palsy children. However (whole body vibration+ reverse walking) provides more clinical benefits than reverse walking alone in improving postural balance, side reach and quality of life. Whereas both techniques were equally effective in improving forward reach in cerebral palsy children.The integration of Artificial Intelligence (AI) into business frameworks has transformed operations, decision-making, and customer engagement, particularly in developed economies. This study explores the profound impact of AI on businesses by examining advancements in automation, data analytics, and strategic decision-making. It also investigates AI-driven business models, associated challenges, ethical considerations, and the evolving regulatory landscape.

Keywords: Cerebral Palsy, Whole Body Vibration, Reverse Walking, Quality of Life, Reach

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Introduction

Cerebral palsy is the most common cause of spasticity and physical disability in children and spasticity is one of the commonest problems in those with neurological disease(1). It produces non-progressive brain abnormalities, resulting in mobility difficulties and influencing sensation, perception, cognition, behaviour, and communication(2). Spasticity, dyskinesia, and hyperreflexia impair motor control of walking, reaching, and object gripping precision (3). Birth problems contribute for just a tiny fraction of Cerebral Palsy occurrences, estimated around 10% (4). Cerebral palsy is a frequent neurologic issue in children, affecting roughly 2-2.5 out of every 1000 live births worldwide. In district Swabi, Khyber Pakhtunkhwa, Pakistan, the prevalence of CP in children was 1.22/1000 live births(5).The majority of afflicted youngsters (39.6 percent) were between the ages of 9 and 10(6). Approximately half of the afflicted youngsters had spastic quadriplegia, and 39.2 percent had severe abnormalities(7).

Cerebral palsy can cause physical disability in various areas such as the arms, legs, and face (8). It can cause muscle weakness, imbalance, and insufficient power output in lower-extremity muscles, such as the ankle plantar-flexor and knee extensor muscles(9). Spastic diplegia cerebral palsy, a condition resulting from brain injury or growth improperly, can cause abnormal delayed myoelectric activation of the medial hamstring (10).Cerebral palsy can also impair balance, posture, and coordination, making activities like walking, sitting, and tying shoes challenging for some (11). Postural control deficits have been suggested to be a major component of gait disorders in cerebral palsy (CP). Most participants with CP had normal dependence on visual feedback to maintain balance, Coordination, steadiness, reactionary reaction, and modulated muscle activity are all difficult for them, and they eschew axial loading, force shifts, and spinal lineup (12).

Among children with Cerebral Palsy who self-report, the quality of life is similar to that of children in the general population, except for in the area of school environment (13). However, parents with higher levels of stress are more likely to report a poorer quality of life for their child (14). Many children with milder forms of cerebral palsy have average survival times similar to those of the general population(15). Children with mild cerebral palsy have a 99% chance of living to 20 years old, whereas children with severe cerebral palsy have a 40% chance of living (16). The whole-body vibration (WBV) exercise is conducted with the subject's body on an oscillating platform which vibrates horizontally at a frequency ranged from 10 to 25 Hz (17).This stimulates the primary endings of muscle spindles and actuates the motor neurons to produce muscle contraction, similar to the tonic vibration reflex(8). Its low-frequency training diminishes the muscle tone in contrast to high frequencies (40 Hz), which expands the muscle tone(18). Therefore, WBV has positive effects on muscle performance. In WBV training, the participant stands on a platform that produces vertical vibrations which invigorate the muscle spindles resulting in reflexive muscle contraction (19).

Backward-walking training (BWT) is a more effective intervention in postural conditioning and walking. BWT improves postural balance and walking ability in children with cerebral palsy and was more significantly associated with the speed and step length of stroke patients than Forward Walking Training (20). Basic neural control mechanism is largely governed by spinal pattern generators, subcortical and cortical structures coordinate their activity, especially when gait is compromised by demanding external conditions or postural instability(21). In addition, despite sharing basic neural control mechanisms, BW requires distinct muscle activation profiles relative to FW because of the dissimilar loads on the musculoskeletal system and is more difficult since one must rely more heavily on senses other than the visual system (22). There is a lack of well-designed randomized clinical trials to investigate the efficacy of reverse walking combined with whole body vibration for postural balance of children with cerebral palsy. Less number of studies has been focused on the positive effects of reverse walking combined with whole body vibration in children with cerebral palsy. This study explored the combined effect of reverse walking and whole-body vibration related to postural balance in children with spastic Cerebral Palsy to provide better treatment techniques to Physiotherapist to improve the prognosis of balance and quality of life, by performing Whole Body Vibration training and reverse walk in children with cerebral palsy.

Material and Methods

Study Design:
The current study was randomized clinical trial.
Setting:
The study was conducted at Department of Physical Therapy, Hussain Memorial Hospital, Lahore.
Duration of Study:
The study was finalized within the time duration of 6 months after the approval of ethical committee of Riphah college of Rehabilitation sciences (RCRS).
Sample Size:
Sample size of 20 patients after adding 10% attrition rate (10 patients in each group) is estimated by using 5% level of significance, 90% power of test with expected mean value for Pediatric Balance Scale (15)

- Z_1-α= confidence level 95%=1.96 Z_1-β= power of test 90%
- μo= Population mean 1= 41.33± 4.67
- $_{\mu\alpha}$= population mean 2= 44.50 ±4.63 Ϭ2=variance
- Group A =10
- Group B = 10

Inputs: "Total sample size (both groups):" 22
Sampling Technique:
Data collection was done by convenience sampling technique.
Assignment In Groups:
According to mentioned criteria of inclusion and exclusion, participants were conscripted and requested to take part in the study. Attendants of study Participants filled written informed consent which was both in English and Urdu.
Group A: Group A was treated with Reverse Walking and Whole Body Vibration along with baseline Physical Therapy Treatment.
Group B: Group B was treated with Reverse Walking along with baseline Physical Therapy Treatment.
Conventional Physical Therapy Treatment was given to both groups as a baseline treatment which includes Stretching, Range of motion exercises, and Strengthening exercises) performed for 10 min.
Sample Selection Criteria:
Inclusion Criteria:

- Aged 6–12 years
- Confirm diagnosis of Cerebral Palsy
- GMFCS level I & II
- Both genders (23).

Exclusion Criteria:
Participants were excluded if they exhibited.

- Visual impairment
- Patients who can't follow command
- Hearing impairment
- Malignancy
- Infection (such as Osteomyelitis)
- Inflammatory arthritis

- Lower extremity bones fracture
- Cardiovascular disease
- Traumatic cases etc. (24).

Data Collection Tools:

- Pediatric Balance Scale (PBS)
- Pediatric Reach Test (PRT) / Functional Reach Test (FRT)
- Cerebral Palsy Quality of Life (CP QOL-Child)
- GMFCS level I & II

Pediatric Balance Scale;

The pediatric balance scale is the modified version of the berg balance scale that is used to assess functional balance skills in school-aged children. The scale consists of 14 items that are scored from 0 points (lowest function) to 4 points (highest function) with a maximum score of 56 points (25).

Pediatric Reach Test (PRT) / Functional Reach Test (FRT)

The Pediatric Reach Test (PRT) is a modified form of the Functional Reach Test (FRT). The PRT measures side reaching as well as forward reaching in both sitting and standing positions. The PRT can be used on typical children and children with disabilities. The patient is instructed to stand next to, but not touching, a wall and position the arm that is closer to the wall at 90 degrees of shoulder flexion with a closed fist. The assessor records the starting position at the 3rd metacarpal head on the yardstick. Instruct the patient to reach forward as far as you can without taking a step. The location of the 3rd metacarpal is recorded. Scores are determined by assessing the difference between the start and end position is the reach distance, usually measured in inches. Three trials are done and the average of the last two is noted. In standing, measures the distance between the lengths of an outstretched arm in a maximal forward reach, while maintaining a fixed base of support. This information is correlated with risk of falling.

Measurement Interpretation:

- 10/25 cm or greater Low risk of falls;
- 6/15cm to 10/25cm Risk of falling is 2x greater than normal;
- 6/15cm or less Risk of falling is 4x greater than normal;
- Unwilling to reach Risk of falling is 8x greater than normal

A number of factors exert a major influence on this evaluation: Research revealed that the movement strategy and a reduced spinal flexibility, both affect the reach distance. (26).

CP QOL-Child

The CP QOL-Child was designed to assess the quality of life of children aged 4-12 years. There are two versions, including a primary caregiver/parent report for children aged 4 to 12 years; and a self-report for children aged 9 to 12 years(27).

GMFCS level I & II

GMFCS Level I

Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited.

GMFCS Level II

Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven surface, inclines, in crowded areas or confined spaces.

Children may walk with physical assistance, a handheld mobility device or use wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping(27).

5.9. TREATMENT APPROACH:

- The data was collected from Department of Physical Therapy, Hussain Memorial Hospital, Lahore.

- The first visit involved the following:
- On the base of inclusion and exclusion measures participants was recruited in the study after taking informed consent from attendant.
- Participants were screened during 1st visit. Attendants of participants answered the questions around and any current complaint or signs patient experienced. Medical history was taken.
- Conventional Physical Therapy Treatment was given to both groups as a baseline treatment which includes Stretching, Range of motion exercises, and Strengthening exercises) performed for 10 min**.**
- Group A received Reverse Walking Training which was provided for 7 min per set, with approximately 3 min of inter-set rest, for a total training duration of 30 min/day, 3 days/week for 3 successive months(15)
- After that Group A received Whole Body Vibration including three vibration sessions per week for three months. The participants have to carry out each set of vibration for 2 min in the first month, and then it was increased to 3 min in the second and 5 min in the third month. The rest period between each set was 1 min in the first month, then it became half a minute in the second and third month. Total training duration is 30 min/day, 3 days/week for 3 successive months.
- Group B received Reverse Walking Training which was provided for 7 min per set, with approximately 3 min of inter-set rest, for a total training duration of 60 min/day, 3 days/week for 3 successive months (15).
- Pre and post intervention assessment was done with respect to Pediatric Balance Scale and Pediatric Reach Test (PRT) / Functional Reach Test (FRT) and Cerebral palsy quality of life (CP QOL-Child).
- Outcomes were measured before and immediately after the 12th week of treatment session.
- Group A received Reverse Walking Training with Whole Body Vibration along with baseline Physical Therapy Treatment.

Group A:

Reverse Walking included gait training on the ground without obstacles. First the therapist helped the participants to move the lower limb correctly when walking backward. The therapist gradually decreased the assistance when the participants underwent training. Second, the participants were trained to cover a distance of approximately 15 m along the corridor of the treatment room. Third, the participants were encouraged to walk independently without a safety bar. Finally, the participants attempted to walk at a comfortable pace of their choice and gradually increased the distance and speed during backward walking. (15) The Whole Body Vibration program comprises standing on and facing hand rails on a vibrating platform. This platform vibrates horizontally at a frequency ranged from 10 to 25 Hz incrementing gradually with amplitude of 2mm. The participants had to carry out each set of vibration for 2 min in the first month, and then it was increased to 3 min in the second and 5 min in the third month. The rest period between each set was 1 min in the first month, then it became half a minute in the second and third month. Total training duration is 30 min/day, 3 days/week for 3 successive months. (1)

Artificial Intelligence (AI) is revolutionizing business frameworks in developed countries, fundamentally altering the way organizations operate, compete, and engage with customers. AI-driven technologies are being integrated into various aspects of business, including automation, data analytics, decision-making, and customer service. Companies are leveraging AI to streamline processes, enhance efficiency, and drive innovation, creating a more agile and responsive business environment. As businesses in developed economies face increasing pressure to stay competitive in the digital age, AI has emerged as a crucial enabler of transformation. The rapid adoption of AI in business frameworks is largely driven by advancements in machine learning (ML), natural language processing (NLP), robotic process automation (RPA), and computer vision (1). These technologies allow businesses to automate repetitive tasks, process vast amounts of data, and generate insights that improve decision-making. AI-powered chatbots, for example, are transforming customer service by providing instant, personalized responses, while predictive analytics enables companies to anticipate market trends and consumer behavior with greater

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accuracy. This AI-driven shift is not only enhancing business performance but also reshaping traditional business models and industry landscapes. One of the key reasons AI is gaining traction in developed countries is the availability of advanced digital infrastructure, including high-speed internet, cloud computing, and data storage facilities. Additionally, substantial investments in AI research and development by both governments and private enterprises have accelerated AI adoption (2). Countries such as the United States, Japan, Germany, and Canada are at the forefront of AI innovation, with government initiatives supporting AI-driven economic growth. Moreover, the highly competitive business environment in these economies has compelled organizations to leverage AI to gain a strategic advantage, improve operational efficiency, and offer enhanced customer experiences.

The evolution of AI in business frameworks has been a gradual yet transformative process. In the early 2000s, AI applications were primarily focused on automation and data analytics, helping businesses streamline processes and extract insights from structured data (3). By the 2010s, advancements in big data, deep learning, and cloud computing enabled businesses to leverage AI for more sophisticated applications, such as personalized recommendations, fraud detection, and demand forecasting. Today, AI is an integral part of business ecosystems, powering intelligent automation, autonomous decision-making, and AI-driven innovation across industries.

AI is not just a tool for process optimization; it is a fundamental shift in business operations and strategy. AI-powered business frameworks emphasize data-driven decision-making, where organizations rely on AI-generated insights to enhance productivity and make strategic choices. Furthermore, AI has enabled businesses to create hyper-personalized customer experiences by analyzing behavioral patterns and preferences (4). Companies like Amazon and Netflix use AI algorithms to recommend products and content tailored to individual users, significantly boosting customer engagement and revenue. In addition, AI-driven agility allows businesses to quickly adapt to market changes, supply chain disruptions, and economic fluctuations, ensuring long-term sustainability. Despite its transformative potential, AI adoption in business comes with challenges, including concerns over data privacy, algorithmic bias, and regulatory compliance. Many businesses struggle with integrating AI into legacy systems, requiring significant investments in infrastructure and workforce upskilling. Governments in developed countries are responding by implementing AI regulations, such as the European Union's AI Act, to ensure ethical and responsible AI deployment (5). Companies must navigate these challenges while maximizing AI's potential to drive efficiency and innovation.

Table 1: Interventions and Protocols in Group A

Intervention	**Treatment protocol**
Baseline	Both groups received a traditional Physical Therapy Program for 12 weeks. Stretching, Range of motion exercises, and Strengthening exercises) was performed for 10 min. (15)
Reverse Walking	Experimental group additionally received Reverse Walking Training which was provided for 7 min per set, with approximately 3 min of inter-set rest, for a total training duration of 30 min/day, 3 days/week for 3 successive months (15)
Whole-Body Vibration	Experimental group additionally received Whole Body Vibration. The participants had to carry out each set of vibration for 2 min in the first month, and then it was increased to 3 min in the second and 5 min in the third month. The rest period between each set was 1 min in the first month, then it became half a minute in the second and third month. Total training duration is 30 min/day, 3 days/week for 3 successive months.

This research aims to explore how AI is revolutionizing business frameworks in developed countries, highlighting the benefits, challenges, and regulatory implications of AI adoption. By examining real-world case studies and emerging AI trends, this paper provides insights into the future trajectory of AI in business and its impact on global

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economic structures. Understanding AI's role in business is essential for industry leaders, policymakers, and entrepreneurs seeking to harness its potential responsibly and sustainably.

Group B:

Group B received Reverse Walking along with baseline Physical Therapy Treatment. Reverse walking included gait training on the ground without obstacles. First, the therapist helped the participants to move the lower limb correctly when walking backward. The therapist gradually decreased the assistance when the participants underwent training. Second, the participants were trained to cover a distance of approximately 15 m along the corridor of the treatment room. Third, the participants were encouraged to walk independently without a safety bar. Finally, the participants attempted to walk at a comfortable pace of their choice and gradually increased the distance and speed during backward walking (15).

Table 2: Interventions and Protocols in Group B

Intervention	Treatment protocol
Baseline	Both groups received a traditional Physical Therapy Program for 12 weeks. Stretching, Range of motion exercises, and Strengthening exercises) was performed for 10 min.(15)
Reverse Walking	Experimental group additionally received Reverse walking training which was provided for 7 min per set, with approximately 3 min of inter-set rest, for a total training duration of 60 min/day, 3 days/week for 3 successive months (15)

Data Analysis Procedure:

The data analysis was done by using SPSS version 26 for windows software. Statistical significance was p = 0.05. Percentage and frequency for descriptive measures such as demographics of gender, age and BMI etc. were calculated. Following tests were applied.

For descriptive statistics bar charts, pie charts, and frequency tables were used.

Paired t-test and independent t-test were used to interpret the results.

Blinding:

The study was single blinded in which subjects were managed to be masked of treatment options available for other groups. Clinicians and assessors could not be blinded due to apparently very different procedures of two groups.

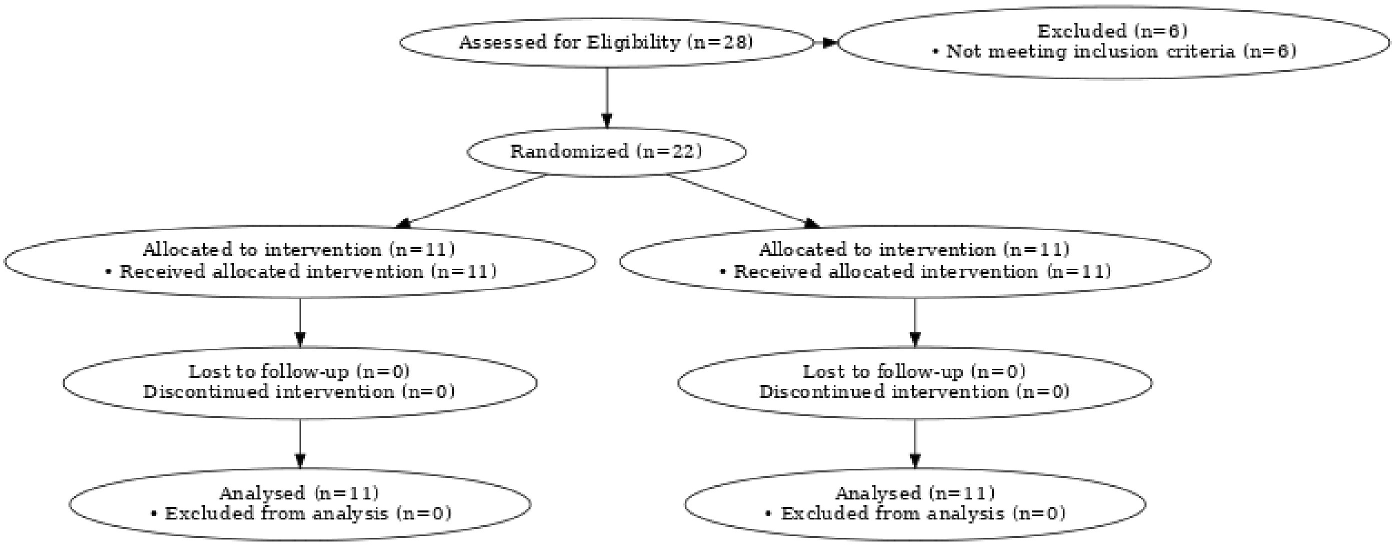

Figure 1: Flowchart

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Results

To test the normality of the data. The Shapiro-Wilk statistic was used. The Findings showed that the **p-value** for all variables is significant, **p > 0.05** which indicates that data is normally distributed. We applied parametric tests for between and within group comparison. The above table shows there were 13 (52%) respondents were 6-8 years old in Group A and 05(44%) respondents were 6-8 years old in Group B. Similarly, there were 03(28%) respondents were 9-10 years old in Group A and 03(28%) respondents in were 9-10 years old in Group B. There were 04(36 %) respondents were 11-12 years old in Group A and 03(28%) respondents were 11-12 years old in Group B. The mean age of participants in Group A was 9.27±2.149.The mean age of participants in Group B was 8.64±2.461. The mean BMI of participants in Group A was 9.27±2.149.The mean A BMI of participants in Group B was 35.24±2.461. In group A (4) 36% were male and (7) 64% were female In group B (7) 64% were male and (4) 36% were female.

The independent t test was used to compare the pre and post treatment means of pediatric balance scale with group A and B. The findings showed that the p-value of pre-treatment is .177 > .05 which is non-significant and indicates that the Whole body vibration + Reverse walking and reverse walking alone were same. Whereas the after treatment showed the significant results as p= <.001 < .05 which showed that difference between the two means is statistically significant. So we reject the null hypothesis. Result indicates that the mean difference in group A is 24.28±0.872 that is more than mean difference in group B is 10.45±1.465 which showed that the Whole body vibration + Reverse walking was more effective than reverse walking alone in improving balance in cerebral palsy. The Independent t test was used to compare the pre and post treatments means of Functional Reach Test (FRT) with group A and B. The findings showed that the p-value of pre-treatment is .217 > .05 which is non-significant and indicates that the Whole body vibration + Reverse walking and reverse walking alone are same. Whereas the after treatment showed the significant results as p= <.001 < .05 which showed that difference between the two means is statistically significant. So we reject the null hypothesis. Result indicates that the mean difference in group A 7.36±0.108 is more than mean difference in group B 1.82±0.567 which shows that the Whole body vibration + Reverse walking is clinically more effective than reverse walking alone in improving Reach(left side) in cerebral palsy.

The Independent t test was used to compare the pre and post treatment means of Functional Reach Test (FRT) with group A and B. The findings showed that the p-value of pre-treatment is .137> .05 which is non-significant and indicates that the Whole body vibration + Reverse walking and reverse walking alone are same. Whereas the after treatment showed the significant results as p= <.001 < .05 which showed that difference between the two means is statistically significant. So we reject the null hypothesis. Result indicates that the mean difference in group A 5.55±0.993 that is more than mean difference in group B 2.33±0.196 which showed that the Whole body vibration + Reverse walking was more effective than reverse walking alone in improving Reach in cerebral palsy. The Independent t test was used to compare the pre and post treatments means of Functional Reach Test (FRT) with group A and B. The findings showed that the p-value of pre-treatment is .527 > .05 which is non-significant and indicates that the Whole body vibration + Reverse walking and reverse walking alone were same. And after treatment showed the results as p= .461 > .05 which is non-significant. So we accept the null hypothesis. Result indicates that the mean difference in group A is 9.91±0.159 is almost same as mean difference in group B is 8.73±0.137 which showed that the Whole body vibration + Reverse walking and reverse walking are clinically equally effective in improving forward Reach in cerebral palsy.

The Independent t test was used to compare the pre and post treatments means of CP QOL-Child with group A and B. The findings showed that the p-value of pre-treatment is .632> .05 which is non-significant and indicates that the Whole body vibration + Reverse walking and reverse walking alone are same. Whereas the after treatment showed the significant results as p= <.001 < .05 which showed that difference between the two means is statistically significant. So we reject the null hypothesis. Result indicates that the mean difference in group A is 136.09±3.866 that is more than mean difference in group B is 80.73±7.613 which showed that the Whole body vibration + Reverse walking were more effective than reverse walking alone in improving quality of life in cerebral

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palsy. The paired t-test showed that there is statistically significant difference **p=<.001** between pre-treatment mean and post-treatment mean which indicated that whole body vibration+ reverse walking improve postural balance, reach and quality of life in cerebral palsy children. The paired t-test showed that there is statistically significant difference **p=<.001** between pre-treatment mean and post-treatment mean which indicated that reverse walking improve postural balance, reach and quality of life in cerebral palsy children.

Table 3: Showing Participants' Demographic

Variables	Categories	Group A	Group B
	6-8	04(36%)	05(44%)
Age, years, n (%)	9-10	03(28%)	03(28%)
	11-12	04(36%)	03(28%)
Gender, n (%)	Male	4(36%)	7(64%)
	Female	7(64%)	4(36%)

Group A=Whole body vibration + Reverse walking, Group B = Reverse walking

The above table shows there were 13 (52%) respondents were 6-8 years old in Group A and 05(44%) respondents were 6-8 years old in Group B. Similarly, there were 03(28%) respondents were 9-10 years old in Group A and 03(28%) respondents in were 9-10 years old in Group B. There were 04(36 %) respondents were 11-12 years old in Group A and 03(28%) respondents were 11-12 years old in Group B.

Table 4: Pre-Post Comparisons for Balance, Reach, and Quality of Life in Group A & Group B

Sr. No	Outcome Measure	Treatment	Group	Mean ± S.D (Pre)	Mean ± S.D (Post)	Mean Difference ± S.D	t-statistic	p-value
1	Pediatric Balance Scale	Pre-Post	A	23.45 ± 4.367	47.73 ± 3.495	24.28 ± 0.872	12.760	<.001
			B	21.00 ± 3.847	31.45 ± 2.382	10.45 ± 1.465	–	<.001
2	Functional Reach Test (Left)	Pre-Post	A	2.82 ± 0.982	9.18 ± 0.874	7.36 ± 0.10	10.283	<.001
			B	3.27 ± 0.647	4.55 ± 1.214	1.82 ± 0.567	–	<.001
3	Functional Reach Test (Right)	Pre-Post	A	3.09 ± 0.831	8.64 ± 0.924	5.55 ± 0.993	9.758	<.001
			B	2.55 ± 0.820	4.36 ± 1.120	1.81 ± 0.196	–	<.001
4	Functional Reach Test (Forward)	Pre-Post	A	12.45 ± 1.753	22.36 ± 1.912	9.91 ± 0.159	0.752	0.461
			B	13.00 ± 2.191	21.73 ± 2.054	8.73 ± 0.137	–	<.001
5	Quality of Life	Pre-Post	A	75.91 ± 14.067	212.00 ± 17.933	136.09 ± 3.866	6.733	<.001
			B	72.91 ± 14.856	153.64 ± 22.469	80.73 ± 7.613	–	<.001

The results demonstrate statistically significant improvements across all measured outcomes in both groups, with Group A (Whole Body Vibration + Reverse Walking) showing superior post-intervention scores compared to Group

B (Reverse Walking alone). A paired t-test revealed a highly significant increase in Pediatric Balance Scale scores for Group A ($t = 12.760$, $p < .001$), with a mean difference of 24.28 ± 0.872. Similarly, the Functional Reach Test scores (Left, Right, and Forward) significantly improved in Group A, with t-values exceeding 9.7 and $p < .001$, indicating a large effect size. Group B also exhibited improvements, though the mean differences were consistently lower than Group A, reflecting a comparatively smaller effect. Quality of Life scores increased substantially in Group A (mean difference = 136.09 ± 3.866; $p < .001$), outperforming Group B's gains. Independent t-tests between groups post-treatment further supported the statistical superiority of the combined intervention. Overall, the findings confirm that the addition of whole-body vibration significantly enhances balance, reach, and quality of life beyond reverse walking alone.

Discussion

Current study concluded that whole body vibration and reverse walking improve postural balance, side reach, forward reach and quality of life in cerebral palsy children. Previous study concluded that for the pre-values of 6 MWT, VJH, and muscle power, there was no critical distinction between both groups ($p = 0.585, 0.893, 0.855$ respectively). There were significant increases in the post-values of both groups compared to their pre-values ($p = 0.001$). The study group's post-values were significantly higher than the post-values of the control group ($p = 0.025, 0.001, 0.014$ respectively).No harmful events were recorded in both groups WBV training is successful in improving the quadriceps and hamstring muscle strength, endurance, and power in children with Hemiparetic CP (3).Current study is consistent with the previous, showed that there is statistically significant difference p=<.001 between pre-treatment mean and post-treatment mean which indicated that whole body vibration+ reverse walking improve postural balance, reach and quality of life in cerebral palsy children.

Previous review showed that the quality of studies ranged from good (two studies) to fair (four studies) and poor (one study), with a mean PEDro score of 4.7 out of 10. All included studies showed positive effects in the measured outcomes. The results showed level 1b evidence for balance when compared to no intervention, and for gross motor function, step length and walking speed when compared to same dose of forward gait training. study provided evidence that backward gait training improves balance, gross motor function, step length and walking velocity(28).Current study is consistent with the previous, concluded that reverse walking improve muscular postural balance and gross motor function in cerebral palsy children. A study in 2021 both groups displayed a significant increase in the intra-group comparison of PBS ($p < 0.05$). The difference between the pretest and post-test analyses in the BWT groups were 3.17 ± 0.40. There was a significant difference in inter-group comparison between the two groups ($p < 0.05$) (22).Current study supports the evidence by Result indicates that the mean difference for pediatric balance scale in group A is 24.28±0.872 that is more than mean difference in group B is 10.45±1.465 which showed that the Whole body vibration + Reverse walking was more effective than reverse walking alone in improving balance in cerebral palsy. A study in 2018 found out that backward walking highlights prominent gait asymmetries in children with hemiplegia and diplopia from cerebral palsy and can give a more comprehensive assessment of gait pathology (29).Current study supports the evidence by concluding that reverse walking improves gross motor function in cerebral palsy children.

M. Saquetto, et all conducted a review showed that Six studies with 176 patients comparing whole-body vibration to exercise and/or control were included. Whole-body vibration resulted in improvement in: gait speed WMDs (0.13 95% CI:0.05 to 0.20); gross motor function dimension E WMDs (2.97 95% CI:0.07 to 5.86) and femur bone density (1.32 95% CI:0.28 to 2.36). The meta-analysis also showed a nonsignificant difference in muscle strength and gross motor function dimension D for participants in the whole-body vibration compared with control group. No serious adverse events were reported. Whole-body vibration may improve gait speed and standing function in children with cerebral palsy and could be considered for inclusion in rehabilitation programs (30).Current study is consistent with the previous, concluded that whole body vibration improves muscular strength and postural balance in cerebral palsy children.

A study in 2015 Whole body vibration training resulted in significantly better gait speed (P = 0.001, from 0.37 (0.04) m/s to 0.48 (0.06)), stride length (P = 0.001, from 0.38 (0.18) m to 0.48 (0.18)) and cycle time (P = 0.001, from 0.85 (0.48) s to 0.58 (0.38)) in the experimental group compared with that in the control group. The ankle angle (P = 0.019, from 7.30 (4.02) degree to 13.58 (8.79)) also showed a remarkable increase in the experimental group, but not the hip (P = 0.321) and knee angle (P = 0.102). The thicknesses of the tibialis anterior (P = 0.001, 0.48 (0.08) mm to 0.63 (0.10)) and soleus (P = 0.001, 0.45 (0.04) mm to 0.63 (0.12)) muscles were significantly higher in the experimental group than in the control group. However, no significant effect was observed in the thickness of the gastrocnemius muscle (P = 0.645) (26). Current study is consistent with the previous, concluded that whole body vibration improves gross motor function in cerebral palsy children.

Shamekh Mohamed et all concluded that Whole-body vibration training may be a useful tool for improving muscle strength and balance in children with diplegic cerebral palsy he children in the experimental group showed a significant improvement when compared with those in the control group (P < 0.001). The peak torque at 60 degrees per second and 90 degrees per second after treatment was 28.8 ± 0.45 and 47.5 ± 0.7 N · m and 30.9 ± 0.68 and 54.2 ± 1.7 N · m for the control and the experimental group, respectively. The overall stability index after treatment was 2.75 and 2.2 for the control group and the experimental group, respectively. (23).Current study is consistent with the previous, concluded that whole body vibration improve muscular strength and postural balance in cerebral palsy children. Byoung-Kwon Lee et all Concluded that these findings suggest that whole body vibration may improve mobility in children with cerebral palsy, probably through a positive effect on the leg muscles(31). Current study is consistent with the previous, concluded that whole body vibration improves mobility in cerebral palsy children.

Tina Makris et all find out that the connection between cerebral palsy and psychosocial quality of life is less clear.All studies provided good to excellent methodological and statistical detail. Physical quality of life was significantly impaired among those with cerebral palsy (g range: −0.42 to −1.58). However, inconsistent findings were noted in relation to the effect of cerebral palsy on psychological (g range: 0.04 to −0.80) and social quality of life (g range: −0.80 to −0.51), depending on the measurement used. There was a trend for parents to evaluate their child's physical quality of life lower than child-reported scores. Quality of life assessment of children with cerebral palsy should extend beyond functional abilities to include less obvious, but critical, psychological and social issues(21).Current study is consistent with the previous, concluded that physical therapy technique improve mobility and ambulation that enable the CP-child to perform their ADLs which in return improves quality of life in cerebral palsy children.

Conclusion

Current study concluded that reverse walking with and without whole body vibration were effective in improving postural balance, reach and quality of life in cerebral palsy children. However (whole body vibration+ reverse walking) provides more clinical benefits than reverse walking alone in improving postural balance, side reach and quality of life. Whereas both techniques were equally effective in improving forward reach in cerebral palsy children.

Limitation

1) Measurements in the study were made only at baseline and after treatment with no supplementary follow-up.
2) Other impairments or factors that affect function and mobility in this population that were not investigated in this study.

Recommendation

1) Research team acclaims future studies to increase duration of treatment period to attain better and sturdy results.
2) It is recommended to evaluate the inter-rater reliability and intra-rater reliability of tool.

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