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Original Research Article

Effect of Speed Intensive Gait Training on Balance, Gait Speed, and Endurance in Patients with Chemotherapy-Induced Peripheral Neuropathy

Geetu Vikram Ahuja *[1], Sabah Thaver [2], Ali Irani [3].

*[1] Post Graduate Student, School of Physiotherapy, NMIMS, (deemed to be) University, Vile Parle, Mumbai, India. **ORCiD:** 0009-0005-0858-4455

[2] Assistant Professor School of Physiotherapy, NMIMS, (deemed to be) University, Vile Parle, Mumbai, India.

[3] HOD, Physiotherapy, Sports Medicine & Rehabilitation, Nanavati Max Super Specialty Hospital, Vile Parle, Mumbai, India.

ABSTRACT

Background: Chemotherapy-induced peripheral neuropathy (CIPN) is a common complication of neurotoxic chemotherapy and is associated with sensory deficits, impaired balance, reduced gait speed, and decreased endurance, resulting in reduced functional mobility and increased fall risk. Exercise-based rehabilitation interventions have shown promise in improving functional outcomes in individuals with CIPN. This study aimed to compare the effects of treadmill training and speed-intensive gait training on balance, gait speed, and walking endurance in individuals with CIPN.

Methodology: A randomized controlled trial was conducted on 46 individuals diagnosed with chemotherapy-induced peripheral neuropathy. Participants were randomly allocated into two groups: Group 1 received balance training combined with treadmill training, while Group 2 received balance training combined with speed-intensive gait training. Both groups underwent supervised intervention for four weeks. Outcome measures included the Mini-Balance Evaluation Systems Test (MiniBESTest), 10-Meter Walk Test (10MWT), and 6-Minute Walk Test (6MWT). Data were analysed using SPSS version 27. Paired t-tests and independent t-tests were used for intra-group and inter-group comparisons, respectively, with the level of significance set at $p<0.05$.

Results: Both groups demonstrated statistically significant improvements in balance, gait speed, and walking endurance following the intervention ($p<0.001$). Significant improvements were observed in MiniBESTest scores, self-selected and fast gait speeds, and 6MWT distances in both groups. However, no statistically significant differences were observed between the groups following the intervention.

Conclusion: Both treadmill training and speed-intensive gait training, when combined with balance training, were effective in improving balance, gait speed, and walking endurance in individuals with chemotherapy-induced peripheral neuropathy. Speed-intensive gait training may serve as a practical alternative to treadmill training in settings where access to treadmill equipment is limited.

KEYWORDS: Chemotherapy-Induced Peripheral Neuropathy, CIPN, Treadmill Training, Speed-Intensive Gait Training, Balance, Gait Speed, Endurance.

Address for correspondence: Dr. Geetu Vikram Ahuja, Post Graduate Student, School of Physiotherapy, NMIMS, (deemed to be) University, Vile Parle, Mumbai, India.
E-Mail: geetuvahuja@gmail.com

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INTRODUCTION

Cancer remains a major global health challenge, with nearly 20 million new cases and 10 million deaths reported worldwide in recent years. The global cancer burden continues to rise, with projections indicating a 77% increase in new cases by 2050. India is also experiencing a growing cancer burden due to factors such as urbanisation, population ageing, sedentary lifestyles, unhealthy diets, and environmental pollution [1].

Chemotherapy is an effective cancer treatment; however, it frequently results in chemotherapy-induced peripheral neuropathy (CIPN), one of the most common neurological complications associated with cancer therapy [2,3]. CIPN affects approximately 30–55% of patients receiving neurotoxic chemotherapeutic agents, with most cases developing within the first month of treatment [3]. It commonly presents with sensory symptoms such as pain, numbness, tingling, and burning sensations, while motor impairments may include muscle weakness, impaired coordination, and balance deficits. In some patients, symptoms persist long after chemotherapy completion, significantly affecting activities of daily living, functional independence, and quality of life [3].

The pathophysiology of CIPN involves axonal degeneration, mitochondrial dysfunction, oxidative stress, neuroinflammation, and impaired axonal transport caused by agents such as platinum compounds, taxanes, vinca alkaloids, and other neurotoxic drugs [4,5]. These mechanisms result in sensory, motor, and occasionally autonomic dysfunction, often producing a characteristic “stocking-glove” distribution of symptoms [4–6].

Balance impairment is a major consequence of CIPN due to disrupted proprioceptive input, sensory loss, muscle weakness, and reduced coordination, leading to gait instability and an increased risk of falls [5]. Physical therapy interventions, including balance training, proprioceptive exercises, resistance training, aerobic exercise, and functional task-oriented rehabilitation, have demonstrated benefits in improving postural stability, motor function, gait performance, and neuropathic symptoms in individuals with CIPN [2,6,7].

Evidence from neurological rehabilitation suggests that speed-intensive gait training can improve walking speed, motor coordination, postural control, and cardiovascular endurance through repetitive, task-specific practice and error-based motor learning [11,12]. While exercise-based rehabilitation has shown promising outcomes in patients with CIPN, limited research has explored the effectiveness of speed-based gait training in this population. Therefore, the present study aims to investigate the effects of a speed-based gait training program on balance, gait, and endurance in cancer patients with chemotherapy-induced peripheral neuropathy.

The aim of this study was to compare the effects of balance training combined with speed-intensive gait training and balance training combined with treadmill training on balance, gait speed, and endurance in patients with chemotherapy-induced peripheral neuropathy.

MATERIALS AND METHODS

Participants included in the study were patients diagnosed with cancer who had completed a chemotherapeutic regimen at least one month prior to enrolment and had received medical clearance for participation. Eligible participants were required to have a score of <76 on the Functional Assessment of Cance Therapy/Gynecologic Oncology Group–Neurotoxicity (FACT/GOG-Ntx) scale, as assessed by the oncology team, and a score of $\geq$ 26 out of 30 on the Montreal Cognitive Assessment (MoCA).

Individuals were excluded if they had neurological complications that could hinder active participation in the study, had undergone recent surgery that restricted participation in the intervention, were currently engaged in or had previously participated in a velocity training programme, or had medical conditions that limited exercise training, including cardiovascular or pulmonary disorders.

This study was conducted over a period of one year. Participants were randomly assigned to

either Group 1 (Balance Training + Treadmill Training) or Group 2 (Balance Training + Speed-Intensive Gait Training) using the Sequentially Numbered, Opaque, Sealed Envelope (SNOSE) method. Forty-two chits were prepared in equal numbers for the two groups. Each chit was folded identically, thoroughly mixed, and placed into sequentially numbered opaque envelopes. The envelopes were sealed to ensure allocation concealment and prevent manipulation.

At the time of enrolment, envelopes were opened sequentially by an independent supervisor who was not involved in participant assessment or intervention delivery. This procedure ensured unbiased group allocation and maintained allocation concealment throughout the recruitment process. The study followed an open-label design; therefore, participants and treating therapists were not blinded to group allocation. However, the data analyst was blinded to group assignment during statistical analysis to minimise potential bias.

All participants underwent a baseline assessment. Demographic information, medical history, and relevant clinical characteristics were recorded. Baseline outcome measures included the Mini-Balance Evaluation Systems Test (MiniBESTest), 10-Meter Walk Test (10MWT), and 6-Minute Walk Test (6MWT).

Participants underwent their respective intervention programmes for a duration of four weeks. Attendance and adherence were monitored throughout the intervention period. All sessions were conducted under the supervision of a physiotherapist, and participants were instructed not to engage in any additional structured exercise programmes during the study period. Safety was monitored throughout each session by assessing participants' general well-being, fatigue levels, and vital signs when required.

At the completion of the four-week intervention period, all outcome measures were reassessed using the same procedures as baseline. All participants received balance training in addition to their allocated gait training intervention over a four-week period. Participants in Group A underwent conventional treadmill training three times per week. Each session lasted approximately 20–30 minutes and was performed at a moderate intensity corresponding to a Rating of Perceived Exertion (RPE) of 3–4 on a 0–10 scale. The protocol consisted of a warm-up period, treadmill walking at speeds adjusted according to individual tolerance, and a cool-down period. Treadmill speed was progressively increased based on participant performance, symptoms, fatigue levels, and safety considerations.

Participants in Group B underwent a supervised speed-intensive gait training programme consisting of 12 sessions over four weeks. Training was performed on an indoor level surface and involved repeated 20-second bouts of walking at the fastest speed possible without running. Rest intervals ranging from one to six minutes were provided between bouts according to the participant's fatigue level. The number of bouts was progressively increased based on tolerance and safety. All sessions were supervised by a physiotherapist, and participants were instructed to maintain their usual level of physical activity throughout the study period.

RESULTS

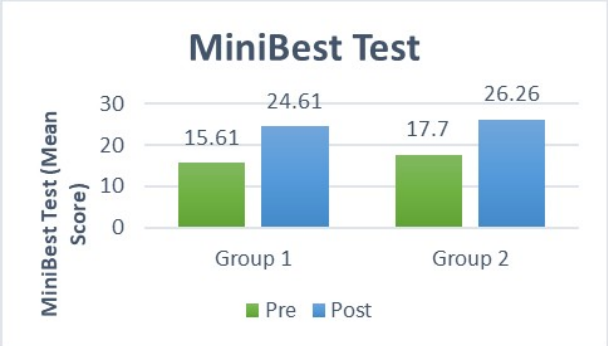
The data analysis was conducted using SPSS version 27. To assess the normality of the data, the Shapiro Wilk test was applied to the primary outcome measures. Since the p-values obtained were greater than 0.05, it was concluded that the data followed a normal distribution. As a result, parametric tests were appropriate for further analysis. Descriptive statistics were used to summarise demographic and baseline characteristics, and continuous variables were expressed as mean ± standard deviation. For inter-group comparisons, paired t-tests were used to assess, while independent t-tests were employed for between-group comparisons. In all analyses, results were considered statistically significant if the p-value was less than or equal to 0.05.

Table 1: Demographic Data.

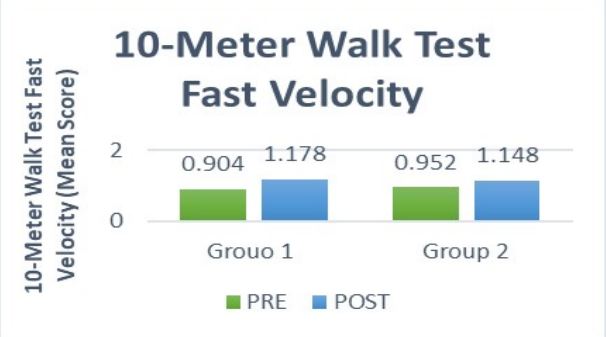
	Group 1	Group 2
AGE (Mean in years)	47.35±10.93	46.17±12.28
Gender (M/F)	4/19	8/15

Table 2: Data Analysis for outcome measures.

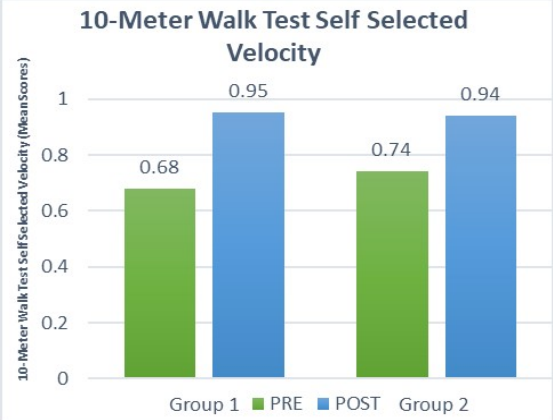
Outcome Measure	Group 1		Group 2	
	PRE	POST	PRE	POST
MiniBESTest	15.61±2.96	24.61±3.78	17.70±2.14	26.26±3.19
p value intragroup	<0.001		<0.001	
p value intergroup (Pre)	0.012			
p value intergroup (Post)	0.117			
10MWT SSV	0.68±0.14	0.95±0.20	0.74±0.15	0.94±0.18
p value intragroup	<0.001		<0.001	
p value intergroup (Pre)	0.211			
p value intergroup (Post)	0.841			
10MWT FV	0.90±0.18	1.17±0.17	0.95±0.22	1.14±0.21
p value intragroup	<0.001		<0.001	
p value intergroup (Pre)	0.433			
p value intergroup (Post)	0.604			
6-Minute Walk Test	274.48±62.68	331.74±61.62	303.35±34.64	357.91±44.79
p value intragroup	<0.001		<0.001	
p value intergroup (Pre)	0.06			
p value intergroup (Post)	0.107			



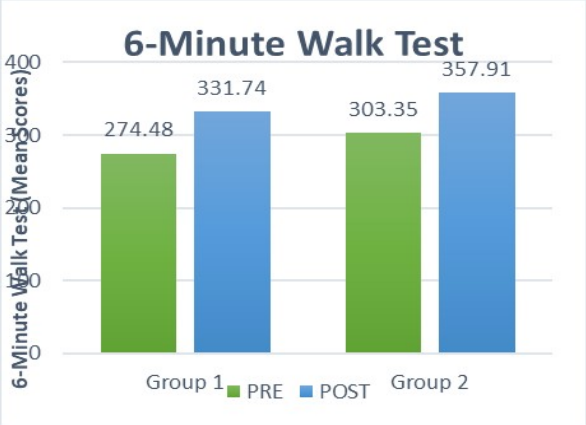
Graph 1: MiniBESTest Test



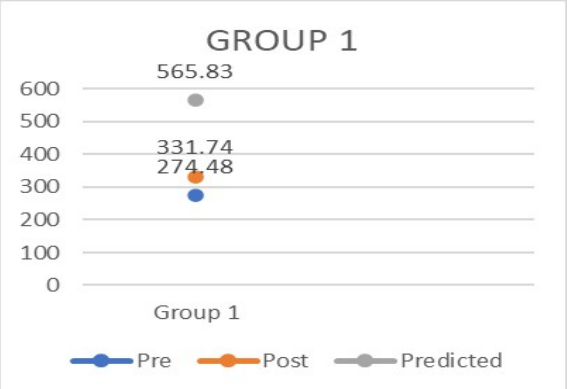
Graph 2: 10-Meter Walk Test Fast Velocity



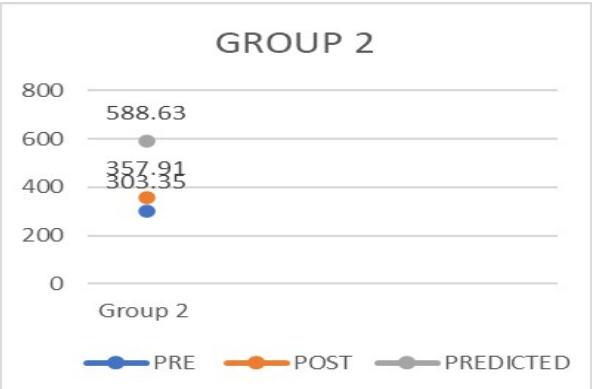
Graph 3:10-Meter Walk Test Self-Selected Velocity



Graph 4: 6-Minute Walk Test



Graph 5: Group 1 6-Minute Walk Test



Graph 6: Group 2 6-Minute Walk Test

The outcome measures demonstrated significant improvements in balance, gait performance, walking speed, and endurance in both groups. The MiniBESTest total score in Group 1 increased from 15.61 (±2.96) to 24..61 (±3.19), while Group 2 improved from 17.70 (±2.14) to 26.26 (±3.04), with significant intragroup changes ($p < 0.001$) and no significant post-intervention intergroup difference ($p = 0.117$).

In the self-paced condition, Group 1 improved from 0.68 (±0.14) to 0.95 (±0.20), and Group 2 from 0.74 (±0.15) to 0.94 (±0.18). Both groups showed significant intragroup improvements ($p < 0.001$), with no significant intergroup difference post-intervention ($p = 0.841$).

In the fast-paced condition, Group 1 improved from 0.90 (±0.18) to 1.17 (±0.17), while Group 2 improved from 0.95 (±0.22) to 1.14 (±0.21). These changes were significant within groups ($p < 0.05$), with no significant intergroup difference post-intervention ($p = 0.604$).

For the 6-Minute Walk Test, Group 1 improved from 274.48 (±62.68) to 331.74 (±61.62), while Group 2 improved from 303.35 (±34.64) to 357.91 (±44.79). Significant intragroup improvements were observed in both groups ($p < 0.05$), with no significant post-intervention intergroup difference ($p = 0.107$).

DISCUSSION

The present study investigated the effects of treadmill training and speed-intensive gait training on balance, gait speed, and endurance in individuals with chemotherapy-induced peripheral neuropathy (CIPN). The findings demonstrated that both interventions produced significant improvements in dynamic balance, gait performance, and walking endurance following the four-week intervention period. However, no statistically significant differences were observed between the two groups, indicating that both approaches were similarly effective in improving functional mobility in individuals with CIPN.

Balance impairment in CIPN is primarily attributed to damage to peripheral sensory nerves, resulting in reduced proprioceptive input, impaired sensorimotor integration, and altered postural control. Previous studies have reported increased postural sway, gait instability, and a higher risk of falls in individuals with CIPN. The significant improvements in MiniBESTest scores observed in both groups may be attributed to the combined effects of balance training and repetitive locomotor practice, which challenge postural contro systems and promote adaptation of sensory and motor pathways.

The improvements in gait speed observed in both groups are consistent with the principles of task-specific training and motor learning. Repeated walking practice facilitates neuromuscular adaptations, improves movement coordination, and enhances locomotor efficiency. These findings are in agreement with previous studies demonstrating that structured gait training can improve walking performance in populations with neurological and sensorimotor impairments. Speed-intensive gait training, in particular, may have promoted greater activation of locomotor pathways by requiring participants to walk at speeds exceeding their habitual walking velocity.

Walking endurance, as measured by the 6-Minute Walk Test, also improved significantly following both interventions. Repetitive walking activities are known to induce cardiovascular and muscular adaptations, including improved aerobic capacity, muscular endurance, and walking efficiency. These physiological adaptations likely contributed to the increased walking distances observed following the intervention period.

The absence of significant differences between treadmill training and speed-intensive gait training suggests that both interventions may produce comparable functional benefits. One possible explanation is that both programmes incorporated repetitive task-specific locomotor practice, which is considered a key determinant of motor recovery and functional improvement. The findings indicate that overground speed-intensive gait training may provide a practical and cost-effective alternative to treadmill-based training, particularly in clinical settings where access to specialised equipment is limited.

The clinical implications of this study are important for oncology rehabilitation. Improvements in balance, gait speed, and endurance may contribute to reduced fall risk, enhanced functional independence, and improved participation in daily activities among individuals with CIPN. Given the increasing number of cancer survivors experiencing long-term neuropathic complications, rehabilitation strategies targeting mobility impairments are essential for improving quality of life.

Several limitations should be considered while interpreting the findings. The study included a relatively small sample size and a short intervention duration, which may have limited the ability to detect differences between interventions. Long-term follow-up was not performed; therefore, the sustainability of the observed improvements remains unknown. Future studies with larger sample sizes, longer intervention periods, and follow-up assessments are recommended to determine the long-term effectiveness of speed-intensive gait training in individuals with CIPN.

CONCLUSION

The findings of the present study indicate that both treadmill training and speed-intensive gait training, when combined with balance training, are effective interventions for improving balance, gait speed, and walking endurance in individuals with chemotherapy-induced peripheral neuropathy. Significant improvements were observed in dynamic balance, functional mobility, and endurance following the four-week intervention period in both groups. However, no significant differences were found between the interventions, suggesting that both approaches provide comparable benefits. These findings support the incorporation of task-specific gait training into rehabilitation programmes for individuals with CIPN to enhance functional mobility, reduce mobility limitations, and improve overall quality of life.

ABBREVIATIONS

CIPN - Chemotherapy-Induced Peripheral Neuropathy
FACT/GOG-NTX - Functional Assessment of Cancer Therapy/Gynaecologic Oncology Group-Neurotoxicity
MoCA - Montreal Cognitive Assessment
ADL - Activities of Daily Living
6MWT 6 - Minute Walk Test
10MWT - 10-Metre Walk Test

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