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Neuromuscular Rehabilitation for Balance and Gait Impairments in Long COVID Condition: A Randomized Controlled Trial

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ABSTRACT:

Introduction: The World Health Organization (2026) defines ongoing/long COVID as Symptoms that persist beyond the initial infection phase, including cognitive difficulties like brain fog.

Current rehabilitation emphasizes integrated strategies targeting neuromuscular control and breathing–posture coordination. Dynamic Neuromuscular Stabilization, grounded in developmental kinesiology, addresses these mechanisms; however, evidence for its effectiveness remains limited. This RCT investigated the effectiveness of Dynamic Neuromuscular Stabilization (DNS) in people with post-COVID condition, focusing on improvement of balance and gait-related neuromuscular impairments.

Methodology: 58 participants with predefined criteria were allocated randomly to two groups (n = 29). Group A received conventional physiotherapy, while Group B received DNS exercises. Outcome measures included the Tinetti Balance and Gait Assessment score.

Result: The analysis was done using SPSS Software. Normality testing of data was checked by the Kolmogorov–Smirnov test, which supported the use of parametric statistical methods. A two-way RM- ANOVA was conducted to test both within-group effects across different time durations (baseline,3rd, and 6th Week) and between-group differences (control and experimental groups). When the assumption of sphericity was not met, appropriate corrections were applied, and Bonferroni-adjusted post-hoc analyses were used for pairwise comparisons. Results revealed a statistically significant time-by-group interaction and a pronounced main effect of time for balance outcomes, $F(2,112) = 110.52$, $p < .001$, reflecting continuous enhancement in Tinetti Balance Scores over the course of the intervention. Similarly, gait outcomes showed a significant main effect of time, $F(2,112) = 124.82$, $p < .001$, indicating progressive improvements across evaluation periods.

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Conclusion: DNS significantly improves balance and gait problems over six weeks, supporting its effectiveness as a targeted physiotherapy neuromuscular rehabilitation intervention in long-term COVID.

INTRODUCTION

In 2026, the World Health Organization redefined its consensus description of Post–COVID-19 Condition (PCC) as a multisystem illness in which persistent or newly developed symptoms continue beyond 12 weeks after initial SARS-CoV-2 infection (1). These symptoms are not attributable to other medical conditions and substantially affect daily routine activities. Post-COVID conditions have also created considerable financial strain on healthcare systems globally. Rising demand for outpatient care, diagnostic procedures, medications, and surgical interventions, along with the need for long-term management, has driven treatment costs higher. These complications have also contributed to a reduced workforce, further impacting the economy. COVID-19 "brain fog," a syndrome of ongoing cognitive impairment characterized by issues with attention, concentration, memory, processing speed, and executive function, is among the most prominent long-lasting neurological effects (2). Common neurological signs include neuropathies, autonomic dysfunction, ataxia, motor abnormalities, dysexecutive syndrome, and cognitive problems, with less frequent neurological consequences (3). Additionally, the condition might lead to difficulties in the peripheral and central nervous systems, such as balance issues and dizziness. This includes changes in gait speed, stride width, spatial and temporal metrics, kinematic factors, or ground reaction forces (GRF). Asymmetrical gait patterns were more common among subjects with a history of infection than among those without (4). Viral proteins or DNA have been detected months or even years after acute infection. According to the study, the RNA virus may persist for 2-3 years following the original infection in people with long-lasting COVID (5).

Often called "long COVID," post-acute sequelae of SARS-CoV-2 infection (PASC) include a variety of chronic symptoms that impact several organ systems. Among the most debilitating consequences are impairments in balance and gait, which significantly reduce functional independence and quality of life (6). The pathophysiology underlying these locomotor deficits is multifactorial, involving direct and indirect viral impact on the neurological system and musculoskeletal apparatus. SARS-CoV-2 has been shown to invade neural tissue via hematogenous spread and retrograde olfactory transneuronal pathways, triggering neuroinflammation, microglial activation, and cytokine release, which can disrupt central and peripheral neural circuits critical for postural control and motor coordination. Hypoxic-ischemic injury, endothelial dysfunction, and small-fiber neuropathy further compromise sensory integration required for balance (shown in Fig.1) (7). Vestibular dysfunction, autonomic dysregulation, and persistent myopathy contribute to gait abnormalities, producing symptoms such as unsteadiness, dizziness, ataxia, and falls (8).

Emerging epidemiological studies report that up to 20–30% of recovered patients experience persistent balance or gait disturbances months after acute illness, even among non-hospitalized cohorts. These impairments are more pronounced in older adults and those with underlying neurological or cardiopulmonary complications, though they occur across all severity levels of initial infection. The prevalence of these symptoms underscores an underrecognized public health burden: impaired mobility leads to loss of independence, increased fall risk, elevated healthcare utilization, and reduced participation in work and social activities (9).

From a health systems perspective, gait and balance abnormalities contribute substantially to post-COVID morbidity, necessitating long-term rehabilitation and multidisciplinary care. Early recognition and assessment using standardized tools (e.g., Berg Balance Scale, Timed Up and Go, instrumented gait analysis) are critical to characterizing deficits and tailoring interventions (6). Rehabilitation strategies should address underlying sensorimotor dysfunction through vestibular therapy, proprioceptive training, neuromuscular re-education, and aerobic conditioning. Considering the scale of the pandemic and the high prevalence of persistent locomotor dysfunction, structured clinical pathways and research into targeted therapeutic modalities are urgently needed to mitigate disability and optimize functional recovery in post-COVID populations.

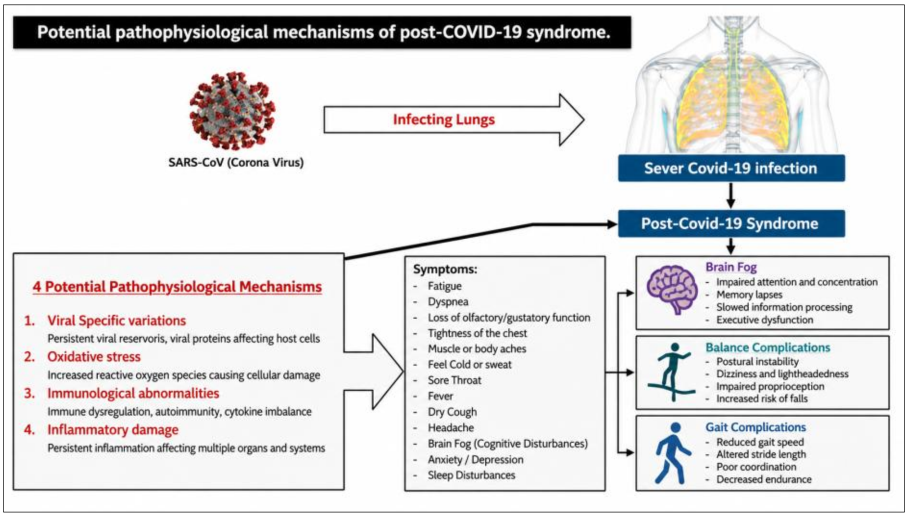

Figure 1: Neurological Complications of Post-COVID-19 Syndrome (*Image generated by biorender)*

Conventional rehabilitation therapy approaches for PCC have primarily focused on symptom-specific treatments such as strengthening, stretching, and aerobic conditioning. While these methods yield modest improvements in isolated outcomes, they may fall short of addressing the integrated neuromuscular control deficits and altered respiratory–postural dynamics frequently observed in PCC. It may not sufficiently address integrated motor control deficits that underlie functional impairment in this population. As rehabilitation strategies evolve, there is a growing emphasis on approaches that restore optimal movement patterns, core stability, and coordinated breathing mechanics to facilitate holistic recovery (10).

Dynamic Neuromuscular Stabilization (DNS), an approach derived its roots from principles of developmental kinesiology as shown in Figure 2, offers a comprehensive approach to motor control retraining by restoring optimal muscle synergies, diaphragmatic breathing, and neuromuscular stabilization across functional movement patterns (11). DNS has demonstrated efficacy in improving postural alignment, reducing musculoskeletal pain, and enhancing functional performance in various chronic pain and movement impairment conditions. These effects are theorized to arise from normalization of afferent feedback, improved central motor programming, and enhanced stability of the lumbopelvic region, which collectively reduce aberrant loading and neuromuscular inefficiency.

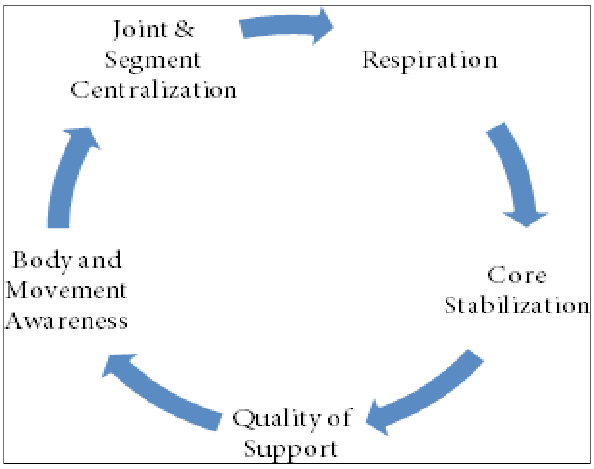

Figure 2: *DNS Principle (image generated by bio-render)*

Evidence suggests that DNS is associated with enhanced postural stability, particularly under internal or external perturbations during dynamic limb activity. It is based on a feedforward stabilization mechanism in which the diaphragm, pelvic floor, abdominal musculature, and spinal extensors coordinate to efficiently generate and regulate optimal intra-abdominal pressure (IAP). It involves both the nervous system and the muscular system (12). The effects of the DNS exercise have been assessed across different populations to study improvements in balance performance and gait parameters. It combines flexibility, core stability, balance, and strength training needed for neuromuscular coordination

Despite growing recognition of post–COVID-19 balance and gait impairments, there remains a limited evidence base to guide targeted rehabilitation strategies for this population. Most current interventions are extrapolated from general neurorehabilitation or vestibular protocols, without specific consideration of the unique sensorimotor dysregulation, altered respiratory mechanics, and impaired postural control observed in post–COVID-19 condition. The technique DNS focuses on restoration of central stability, diaphragmatic function, and coordinated neuromuscular control—mechanisms that may directly address the underlying pathophysiological disturbances contributing to post-COVID locomotor dysfunction. However, empirical investigation into its effectiveness in this context is lacking.

Because of the prevalence of neurological dysfunction following infection and the limited evidence guiding targeted rehabilitation in this population, there is a critical need to evaluate interventions that address underlying neuromuscular and respiratory–postural dysregulation. Therefore, this study aimed to assess the impact of a systematic Dynamic Neuromuscular Stabilization (DNS) program on gait metrics and balance parameters in people with post-COVID-19 symptoms.

METHODOLOGY

Study design

This assessor-blinded randomized control trial (RCT) was carried out under the Department of Physiotherapy at Lovely Professional University (LPU) from May 2023 to December 2025. The study protocol was registered with ClinicalTrials.gov (XXX), and the Institutional Ethics Committee granted ethical clearance (Ethical approval No. XXX). All participants gave written informed consent before participation, and the study's methods complied with the Declaration of Helsinki's ethical guidelines. Participants were allocated randomly into study groups using a computer-generated sequence created through a web-based randomization platform (www.randomization.com). Sequentially numbered sealed opaque envelopes created by another separate investigator who was not involved in recruiting, assessment, or treatment delivery were asked to preserve allocation concealment. The assigned envelope was opened by the treating physiotherapist immediately before the intervention session. A double-blind trial design was maintained throughout the investigation by keeping both participants and the result assessor blind.

Participants

Participants were adults of both genders, aged 18–45 years, with Subjects clinically diagnosed with COVID-19 by RT-PCR report positive and have post-COVID-19 syndrome based on the WHO PCC definition. Inclusion required subjects with no pre-existing deformity and reduced functional efficiency, balance, and gait abnormalities developed after acute infection. Exclusion criteria included: pregnancy, malignancy, neurological conditions like vestibular/cerebellar disorders, post-COVID stroke patients, pre-existing arthritis, cardiovascular conditions like pacemakers, surgery with metal implants, recent fractures(<6 months), and infective skin conditions around the knee and spine.

Outcome Measures

At baseline, mid-point intervention (Week 3), and post-treatment (Week 6), all study outcomes were assessed as primary outcome measures. Assessments were done by trained evaluators who were blinded to group allocation in order to maintain objectivity and reduce bias.

- Tinetti balance and gait Measurement scale

Used for balance and gait measurement, the test includes 17 items, each scored on a scale of 0, 1, or 2, resulting in a highest score of 28 points. Administering the TMT takes around 10 minutes per participant. The TMT evaluated in this research has two separate components:

Tinetti balance assessment score: A balance subscale consists of 9 items and a total of 16 points. The interrater reliability for the balance subscale is high, with values ranging from 0.94 to 0.98 and an ICC of 0.97. Test-retest reliability, indicating intra-rater consistency, was ICC = 0.97 for the balance sub-scale. The Tinetti Balance Assessment demonstrated acceptable internal consistency, with a Cronbach’s alpha value of 0.74 and a confidence interval ranging from 0.69 to 0.77 (13).

Tinetti gait assessment score: The gait subscale comprises 8 items, with a maximum score of 12 points. The tool demonstrated excellent inter-rater reliability, with values ranging from 0.90 to 0.97 and an intraclass correlation coefficient (ICC) of 0.94. Intra-rater reliability assessed through test–retest analysis also showed high consistency (ICC = 0.96). Furthermore, the gait subscale exhibited acceptable internal consistency, with a Cronbach's alpha value of 0.72 and a confidence interval ranging from 0.67 to 0.70 (13).

INTERVENTIONS

Conventional Therapy (Group A)

Participants received conventional therapy, including isometric muscle strengthening exercises for weak muscles like the quadriceps, the upper trapezius muscle, and the paraspinal musculature for the spine (14). Each session lasted 20 minutes, with 6-second contractions and 4-second rest intervals. Additionally, transcutaneous electrical nerve stimulation (TENS) was applied for 20 minutes per session, frequency 1–20 Hz, and pulse width 150–300 µs (15).

Experimental Group (Group B)

Participants received Dynamic Neuromuscular Stabilization (DNS) exercises (Copyright Registration Number: L-128437/2023). The DNS program consisted of three progressive levels—simple, intermediate, and advanced, with each level performed for two weeks (Figure 2). The intervention will include exercises performed in the 3-month position, side-lying, quadrupod, oblique sit, bear, and squatting position for 30–60 s for five repetitions. Progression was done by introducing the Thera bands and the Swiss ball exercises (16).

Each intervention was administered with the supervision of a physiotherapist with >10 years of musculoskeletal rehabilitation experience, with a frequency of five sessions per week for six weeks.

Additional data collected comprised demographic and clinical variables, including age, sex, and the duration since COVID-19 infection, to characterize the study population and control for potential confounding factors.

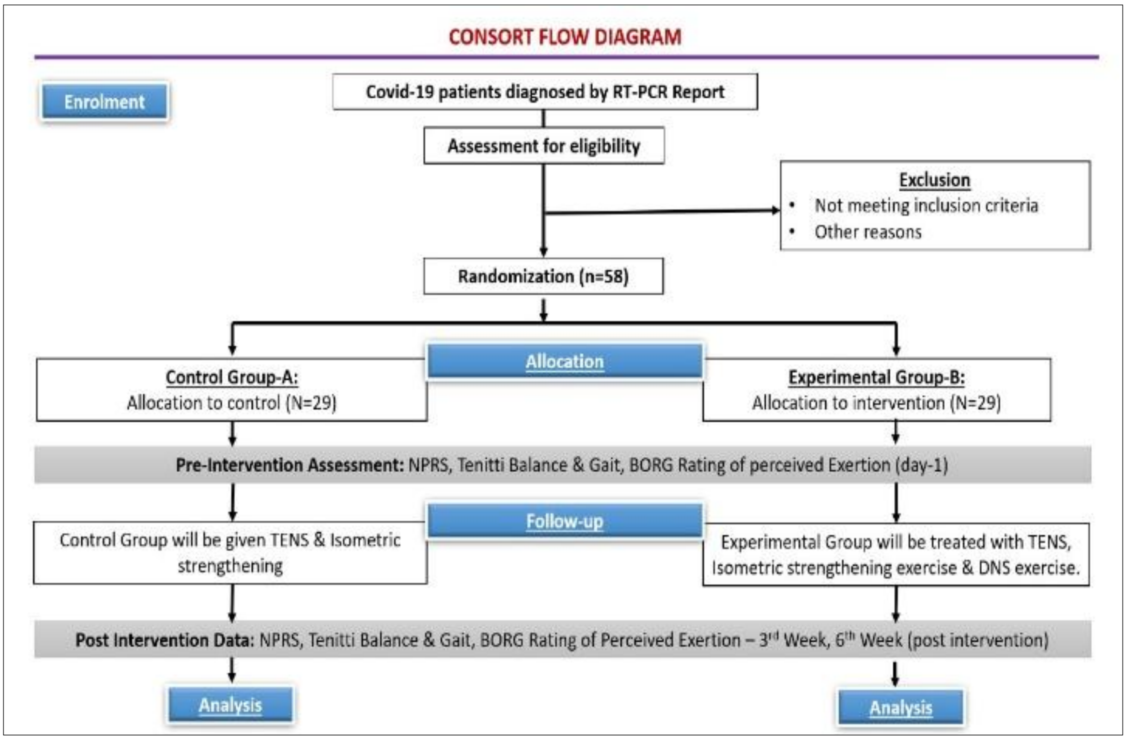

Figure 1: CONSORT Flow Chart

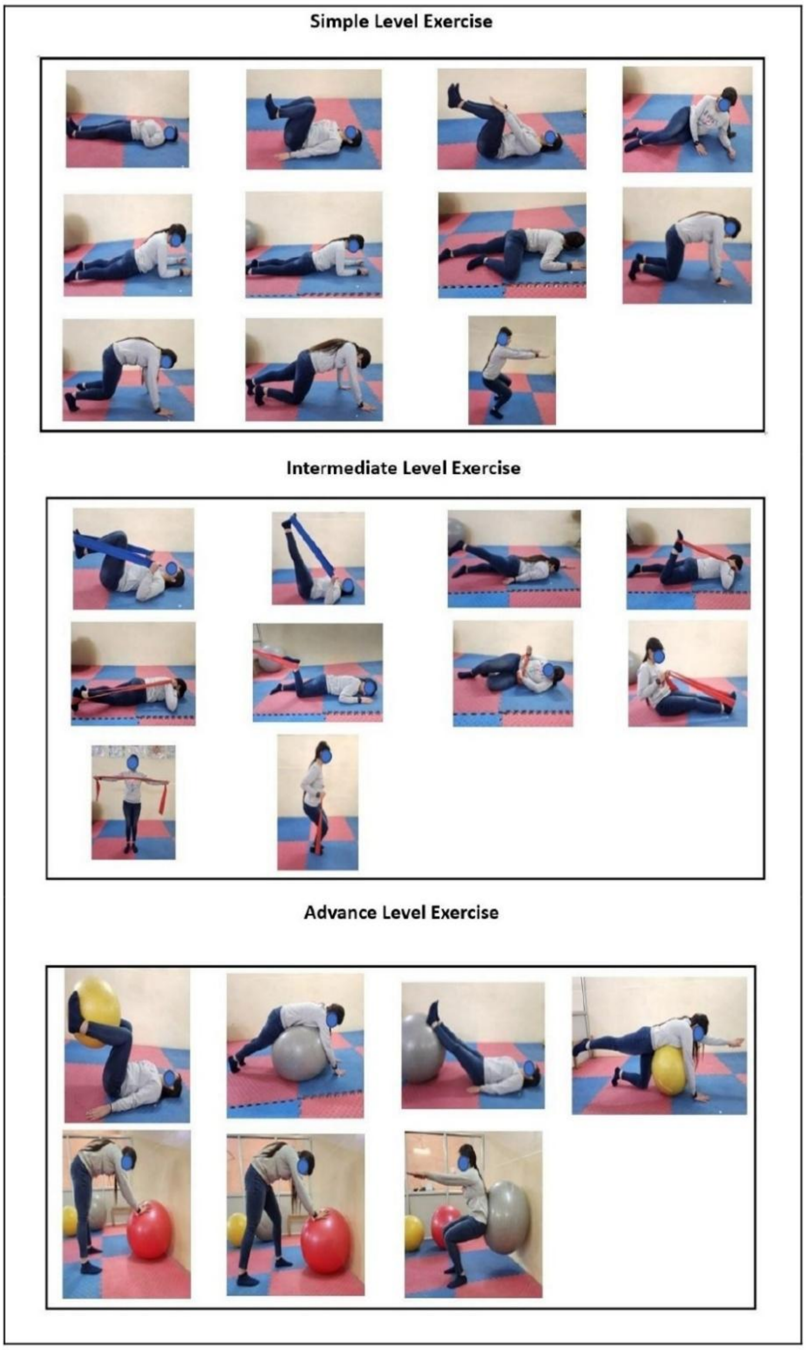

Figure 2: Dynamic Neuromuscular Stabilization Exercise protocol

Sample size:

The sample size was calculated with G*Power software. The analysis was based on a repeated-measures ANOVA design with within–between group interaction, considering an anticipated moderate-to-large Effect size as 0.75, a threshold of 0.05, and a power 80% ($1-\beta = 0.80$) (17). According to the calculation, at least 28 participants were required in each group to detect statistically meaningful differences among the three intervention groups, yielding a total sample size of 58 participants.

Statistical analysis

Statistical analysis was performed by SPSS software version 29 installed on a Windows 11 operating system. The analysis was conducted on a system featuring an 11th Generation Intel® Core™ i3-1125G4 processor operating at 2.00 GHz, 8 GB RAM, 64-bit operating system architecture, and 238 GB storage capacity. To enhance data accuracy and reduce entry-related errors, data coding and verification were independently completed by two researchers. The normality testing of data was done using the Kolmogorov-smirnov test. Differences between groups and changes across different assessment periods were analyzed using a two-way repeated-measures analysis of variance (ANOVA). For significant group × time interactions, Tukey's HSD post hoc analysis was performed to determine pairwise differences between groups at specific time points. The level of significance was set at a p-value < 0.05.

RESULTS

58 participants (mean age: 31:83 _ 2:33 years) satisfied the inclusion criteria and completed the study, with no dropouts (Fig. 4). The demographic characteristics of the participants are summarized in Table 1. Analysis of baseline demographic and clinical parameters showed no significant differences between the three study groups ($p > 0.05$), suggesting that the groups were well matched before the intervention.

Participant Characteristics

Fifty-eight participants were included, with 29 per group. In Group A (control), 58.6% were male, and the remaining 41.4% were female, with a mean age of 31.38 ± 8.31 years, while Group B (experimental) had 62.1% males and 37.9% females, with a mean age of 32.55 ± 9.15 years (Table 1). Significant differences were not noted between the groups for age or sex composition, indicating baseline equivalence.

Table 1. Participant Demographics

Group	n	Age (Mean ± SD)	Male, n (%)	Female, n (%)
Control (A)	29	31.38 ± 8.31	17 (58.6%)	12 (41.4%)
Experimental (B)	29	32.55 ± 9.15	18 (62.1%)	11 (37.9%)

(Groups were comparable in age and sex distribution).

Analysis of the Tinetti Balance Score:

Both groups exhibited gradual improvements in balance performance throughout the study period, however, the Experimental Group showed a greater and more consistent increase (from 10.0 at baseline to 14.1 at Week 6) compared with the Control Group (from 11.0 to 13.1 over the same period), as shown in Figure 3.

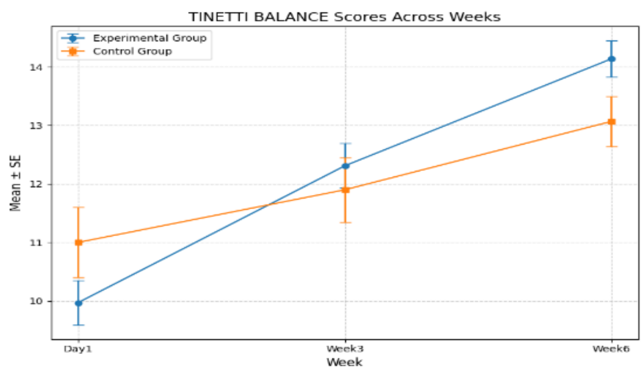

Figure 3: Analysis of Tinetti Balance Score (day 1, week 3, week 6)

A statistically significant effect of time was recorded by two-way RM- ANOVA, $F(2,112) = 110.52$, $p < .001$, $\eta^2 = .21$, $\eta p^2 = .66$, indicating that Tinetti Balance Scores improved significantly across the three measurement points regardless of group. This represents a large effect size, suggesting that time accounted for a substantial proportion of variance in balance scores. The main effect of group was not statistically significant, $F(1,56) = 0.06, p = .803, \eta^2 = .00, \eta p^2 = .00$, indicating that the Experimental and Control groups did not differ significantly in balance scores when measurements were averaged across all time points. A significant interaction between time and group was identified, $F(2,112) = 13.14, p < .001, \eta^2 = .03, \eta p^2 = .19$, with a moderate effect size. The results show that the Experimental Group exhibited a steeper and more consistent increase in balance scores over time than the Control Group(Table 2).

Table 2: Analysis of Variance for Tinetti Balance Score

	Sum of squares	df	Mean Squares	F	p	η^2	η^2_p
Day 1, Week 3, Week 6	282.56	2	141.28	110.52	<.001	0.21	0.66
Group of Patients	0.97	1	0.97	0.06	0.803	0	0
RM Factor x Group of Patients	33.6	2	16.8	13.14	<.001	0.03	0.19
Residuals (Between Subjects)	862	56	15.39				
Residuals (Within Subjects)	143.17	112	1.28				

Bonferroni-adjusted pairwise comparisons for the time factor confirmed that balance scores improved progressively across all measurement points. The Experimental Group demonstrated significant improvements across all time intervals (Day 1–Week 3 ≈ +2.34, $p < .001$; Day 1–Week 6 ≈ +4.17, $p < .001$; Week 3–Week 6 ≈ +1.83, $p < .001$) (Table 3).

Table 3: Bonferroni Post-hoc-Tests RM Factor for Tinetti Balance score

		Mean diff.	Std. Error	t	p	95% CI lower limit	95% CI upper limit
Day 1	Week 3	-1.62	0.203	-8.001	<.001	-2.03	-1.21
Day 1	Week 6	-3.12	0.302	-10.323	<.001	-3.73	-2.52
Week 3	Week 6	-1.5	0.167	-8.968	<.001	-1.84	-1.16

Minimal Detectable Change (MDC) for the Tinetti Balance Score demonstrated an improvement of 4.17 points from Day 1 to Week 6, exceeding the MDC threshold in the experimental group, as presented in Table 4.

Table 4: Achievement of MDC in the Tinetti Balance Score from Day 1 to Week 6

Group	Day 1 Mean ± SD	Week 6 Mean ± SD	Mean Change	MDC (3 points) Achieved?
Experimental	9.97 ± 2.06	14.14 ± 1.68	4.17	Yes
Control	11.00 ± 3.22	13.07 ± 2.31	2.07	No

Tinetti Gait Score Assessment

The changes in gait scores over time for both groups are illustrated in Figure 4. Both groups demonstrated progressive improvement over time, indicating overall gains in gait performance. At baseline (Day 1), both groups had comparable scores (Experimental ≈ 8.8, Control ≈ 9.0), suggesting no substantial initial difference. By Week 3, both groups showed improvement, but the Experimental Group exhibited a greater increase (≈ 10.1) than the other group (≈ 9.7). By Week 6, this trend became more significant, with the Experimental Group reaching a mean gait score of ≈ 11.4, while the Control Group achieved ≈ 10.7. The steeper trajectory of improvement in the Group B compared to Group A suggests that the intervention facilitated more rapid gains in gait function. Although both groups improved with time (main effect of time), the widening gap between the two groups by Week 6 indicates a potential time × group interaction, meaning the Experimental Group benefited more substantially from the intervention.

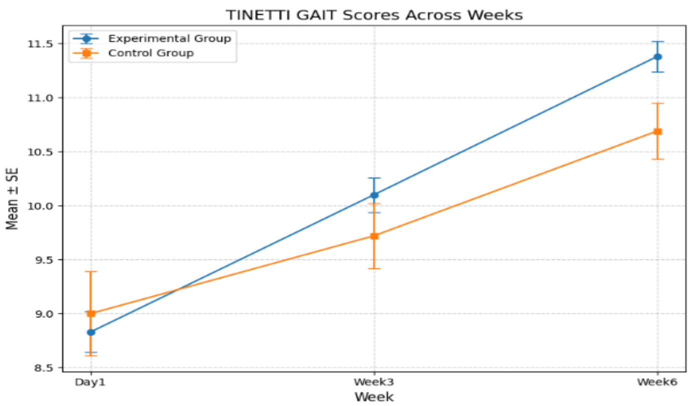

Figure Error! No text of specified style in document.: Analysis of Tinetti gait Score (day 1-week 6)

A RM-ANOVA revealed a statistically significant interaction effect between time and group, F (2,112) = 5.29, p = 0.006, $\eta^2 p$ = 0.09. This finding suggests that changes in gait scores over time varied between the groups, with participants in the experimental group showing greater improvement compared to those in the other group (Table 5).

Table 5: RM-ANOVA for Tinetti gait Score

	Sum of squares	df	Mean Squares	F	p	η^2	η^2_p
Day 1, Week 3, Week 6	130.56	2	65.28	124.82	<.001	0.29	0.69
Group of Patient	3.89	1	3.89	0.85	0.362	0.01	0.01
RM Factor x Group of Patient	5.53	2	2.76	5.29	0.006	0.01	0.09

Bonferroni-adjusted comparisons showed improvement in gait scores from Day 1 to Week 3 (mean diff. ≈ –1.0, $p < .001$), with further improvement by Week 6 (Day 1 vs. Week 6 mean diff. ≈ –2.12, $p < .001$; Week 3 vs. Week 6 mean diff. ≈ –1.12, $p < .001$), indicating a consistent and progressive enhancement in gait function throughout the intervention period shown in Table 6.

Table 6: Bonferroni Post-hoc-Tests RM Factor

		Difference of Mean	Std. Error	t	p	lower limit(CI 95%)	upper limit (95% CI)
Day 1	Week 3	-1	0.128	-7.824	<.001	-1.26	-0.74
Day 1	Week 6	-2.12	0.165	-12.842	<.001	-2.45	-1.79
Week 3	Week 6	-1.12	0.121	-9.286	<.001	-1.36	-0.88

The Minimal Detectable Change (MDC) for the Tinetti Gait subscale was established at 3 points according to previously reported reliability values. From Week 1 to Week 6, the experimental group demonstrated an average improvement of 2.55 points, while the control group improved by 1.69 points. However, neither group reached the MDC threshold. These results indicate that although gait performance improved numerically in both groups, the observed changes did not surpass the level of measurement error and therefore may not represent clinically significant improvement shown in Table 7.

Table 7: Achievement of MDC for Tinetti gait score

Group	Week 1 Mean ± SD	Week 6 Mean ± SD	Mean Change	MDC (3 points) Achieved?
Experimental	8.83 ± 1.00	11.38 ± 0.73	**2.55**	**No**
Control	9.00 ± 2.12	10.69 ± 1.39	**1.69**	**No**

DISCUSSION

Post-COVID musculoskeletal problems have created a significant economic burden on healthcare systems worldwide. There is growing clinical evidence that Dynamic Neuromuscular Stabilization (DNS) exercises are beneficial in the management of various musculoskeletal disorders. The concept proposed by Professor Pavel Kolar is based on a neurodevelopmental approach. It focuses on optimal respiratory exercise patterns by diaphragm stabilization and integrated mechanical activation of the stabilization system of the spine before initiating movements in the extremities. The treatment approach evaluates stability, quality, or movements to regain the spine's integrated stabilizing system through special exercises based on the child's motor position (12). DNS reduces pain by restoring ideal movement patterns derived from developmental kinesiology, enhancing core stability through the coordinated activation of deep stabilizing muscles. By promoting proper joint centration and neuromuscular control, DNS alleviates mechanical stress, muscle imbalances, and compensatory movements that often lead to pain. It also engages the central nervous system to correct faulty motor patterns and incorporates diaphragmatic breathing to manage intra-abdominal pressure and soothe the nervous system. Collectively, these effects enhance functional stability and efficiency of movement, ultimately improving balance and gait. This concept has been supported by previous literature on DNS (18). During dynamic limb movement, the DNS is connected to postural stability in reaction to internal or external disturbances. As discussed earlier, the feedforward process enables the ISSS mechanism to regulate IAP. It entails strengthening the neuromuscular system for improving dynamic as well as static stability (19).

Joint centration in DNS refers to the optimal alignment and positioning of a joint to maximize stability and efficient force transfer during movement. Optimal central nervous system control, combined with balanced muscular activation, ensures joint centration in both movement and resting positions. This joint centration is a dynamic neuromuscular principle that provides a mechanical advantage by reducing excessive load on joints throughout the range of motion. It also relieves abnormal strain across soft tissue structures such as ligaments and tendons, minimizing strain and protecting joint structures during the tension phase. DNS exercises integrate the optimal functioning of the ISSS mechanism by activating the diaphragm, pelvic girdle, abdominals, and back extensors of the lower thoracic and lumbar regions. This reduces mechanical stress preventing overactivation of the muscles, which improves the gait pattern (18). An RCT conducted on patients with multiple sclerosis on balance and trunk function found that 5 weeks of DNS showed effective improvement. Thus, the technique demonstrated strong efficacy in individuals with somatosensory or movement impairments. By retraining breathing patterns and trunk control, it promotes better coordination and weight transfer during walking (20).

As per the outcome of this study, it is suggested that DNS exercises should be included in the treatment protocol by physicians, physiotherapists, pain management clinics, COVID rehabilitation centres, and corrective exercise centres.

Limitations of the study and future scope

The study has certain limitations, including a short treatment duration and a limited number of sessions, which restrict the ability to conclude the long-term effectiveness of the interventions, as no follow-up assessments were conducted. While the Omicron and Delta variants were assumed to be the dominant strains during the study period, no conclusive evidence was available to confirm their prevalence.

In the DNS methodology, core body muscles and respiratory muscles are engaged concurrently, setting it apart from other methods. This simultaneous activation may offer distinct advantages; however, the beneficial effects of these exercises may diminish following a period of detraining. Thus, more studies should be conducted on the long-term efficacy of DNS exercises. The study should be conducted over a more diverse population.

CONCLUSION

Since the onset of the pandemic, post-COVID-19 conditions have affected millions of individuals globally. As the SARS-CoV-2 virus continues to circulate, complications due to COVID-19 remain a significant and ongoing public health concern worldwide. Currently, research on the management of post-COVID-19 syndrome is limited. To fill this gap, this research study evaluated the effectiveness of physiotherapy, specifically the Dynamic Neuromuscular Stabilization (DNS) approach, offering early evidence on a targeted rehabilitation strategy where the benefits of post-COVID rehabilitation are still unclear. DNS, through its focus on restoring optimal neuromuscular control and postural stability, demonstrates potential improvements in pain, balance, and gait mechanics, thereby addressing the lack of research on intervention outcomes for this population. An intervention grounded in developmental kinesiology provides the first evidence that motor-control approaches based on the ISSS model may be effective for post-COVID-19 patients (21). The work may be the first to systematically test the novel approach on this population, establishing it as a potentially effective rehabilitation framework.

Implications for Physiotherapy Practice and Research

This study examined the efficacy of Dynamic Neuromuscular Stabilization (DNS) as a structured intervention for long COVID rehabilitation, particularly in addressing neurological complications of balance and gait. The findings reinforce the role of physiotherapy in mitigating long-term sequelae, reducing healthcare utilization, and supporting functional recovery in individuals with post-COVID-19 conditions.

The results highlight the potential of physiotherapy interventions to influence not only physical outcomes but also cognitive symptoms, including brain fog. Improvements in neuromuscular control and breathing–posture coordination may contribute to enhanced cognitive function, offering a broader scope for physiotherapy in post-COVID care.

From a clinical perspective, these findings support integrating DNS-based approaches into rehabilitation programs to optimize recovery and facilitate return to daily activities and work. The study contributes to the emerging evidence-based research implications for targeted, mechanism-driven interventions in long COVID rehabilitation and underscores the need for additional high-quality trials to validate and standardize these protocols.

Overall, this work emphasizes the expanding role of physiotherapy in addressing both physical and cognitive dimensions of post-COVID-19 condition, with implications for improving patient outcomes and informing future rehabilitation guidelines.

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