

Innovations

“Effectiveness of Walking on Grass Surface on Improving the Static Balance of Subjects with Chronic Stroke”

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Abstract

Background: A major contributor to long-term disability, stroke frequently leaves victims with impaired static balance, which increases fall risk and limits functional independence. While conventional rehabilitation techniques improve balance, walking on different surfaces, particularly grass, may offer additional benefits by enhancing sensory input and neuromuscular coordination. **Objective:** This study sought to ascertain the efficacy of walking on grass surfaces in improving the static balance of individuals with chronic stroke. **Methods:** A quasi-experimental pretest-posttest study was conducted with 30 chronic stroke patients were split up into an experimental group (n=15) undergoing a four-week grass-walking intervention and a control group (n=15) continuing standard rehabilitation exercises. Balance improvements were evaluated utilizing the Berg Balance Scale (BBS) and the One-Leg Stand Test (OLST). **Results:** The experimental group showed notable improvements in static balance compared to the control group. The BBS scores increased from a mean of 31.6 to 34.3 within the experimental group (p=0.000), whereas the control group displayed a smaller increase from 31.5 to 33.4 (p=0.000). Similarly, OLST performance improved significantly within the experimental group (pre-test: 7.87 sec, post-test: 10.53 sec, p=0.000) in contrast to the control group (pre-test: 8.13 sec, post-test: 10.67 sec, p=0.000). The independent t-test further confirmed a statistically significant variation among the groups. (BBS: t=3.0, p=0.002). **Conclusion:** Walking on grass enhances static balance in chronic stroke patients by stimulating proprioception, improving neuromuscular control, and increasing postural stability. Incorporating grass-walking into rehabilitation programs may provide a cost-effective, natural, and interesting method to lower fall risk and

enhance balance in stroke survivors. To investigate long-term impacts and applicability in various stroke populations, more research is advised.

Keywords: *Stroke, static balance, rehabilitation, grass walking, proprioception, postural stability.*

Introduction:

Stroke ranks among the primary contributors to long-term disability across the globe. Common post-stroke complications include aphasia, depression, motor function impairment, balance issues, visual impairments, cognitive limitations, and perceptual deficits¹. Hemiparesis is the most common symptom following a stroke². One of the major challenges faced by stroke survivors, especially those in the chronic phase, is impaired static balance, which increases the chance of falls³. A sedentary lifestyle and deconditioned state are common among stroke survivors, which restricts daily activities⁴. The ability to stand with a stable posture is known as static balance, which is crucial for ensuring safety and independence in movement. Stroke-induced neurological damage often leads to asymmetric weight distribution, reduced proprioception, and weakened postural control, making balance rehabilitation a critical component of stroke recovery⁵.

Various rehabilitation strategies have been explored to improve balance in individuals with chronic stroke. Conventional physiotherapy techniques, including strength training, weight-bearing exercises, and balance retraining, have demonstrated positive effects on postural control⁶. However, recent studies suggest that walking on different types of surfaces, particularly grass, may provide additional benefits by engaging multiple sensory and neuromuscular systems simultaneously. Walking on grass introduces an uneven and soft terrain that requires continuous postural adjustments, thereby stimulating the somatosensory system and enhancing balance-related neural adaptations⁷.

Grass walking is different from walking on rigid surfaces such as concrete or tiled floors because it presents small but continuous perturbations that require greater ankle, knee, and hip coordination. This variability in surface texture encourages the activation of proprioceptors and balance-related muscle groups, promoting improved postural stability and weight-shifting ability⁸. Moreover, walking on grass enhances tactile feedback from the feet, which is essential for individuals with stroke-related sensory deficits. Enhanced sensory input contributes to better integration of balance control mechanisms, ultimately leading to improvements in static balance⁹.

Studies examining the effects of uneven terrain walking in stroke rehabilitation have primarily focused on dynamic balance and gait improvements. However, limited research has specifically investigated the role of grass walking in improving static

balance. In activities such as standing, reaching, and transitioning between movements static balance is essential, all of which are fundamental for performing daily tasks independently¹⁰. Incorporating natural terrain walking, such as grass-based interventions, into rehabilitation programs may provide a cost-effective and accessible means of enhancing postural stability and minimizing the likelihood of falls among individuals with chronic stroke.

Physiological Mechanisms Improving Balance on Grass

Balance is a complex physiological process involving multiple sensory systems, neuromuscular coordination, and motor control strategies. Walking on a grass surface presents unique challenges that engage various physiological mechanisms, ultimately enhancing static and dynamic balance. The key physiological adaptations that contribute to improved balance on grass include enhanced proprioception, neuromuscular control, postural reflex activation, and sensory integration.

1. Enhanced Proprioception and Sensory Feedback

The ability of the body to perceive its position and movement, or proprioception, is essential for preserving equilibrium. Walking on an uneven grass surface stimulates the mechanoreceptors in the feet, ankles, and lower limbs, increasing proprioceptive awareness⁹. The soft and variable texture of grass provides continuous changes in terrain, requiring greater reliance on proprioceptive input for postural adjustments. This heightened sensory feedback enhances balance control by improving the body's ability to detect and correct positional errors in real time⁸.

2. Activation of Postural Reflexes

The instability associated with grass walking necessitates continuous engagement of postural reflexes, which are crucial for maintaining balance. The body responds to minor perturbations by activating automatic postural responses, such as ankle and hip strategies, to regain stability¹¹. Training on a grass surface strengthens these reflexes over time, making balance corrections more efficient and lowering people's risk of falling with compromised postural control, such as stroke survivors.

3. Increased Neuromuscular Control and Strength

Walking on a soft, uneven surface requires greater muscle activation compared to walking on firm ground. The stabilizing muscles of the lower limbs, including the tibialis anterior, gastrocnemius, quadriceps, and gluteal muscles, are more actively engaged to compensate for surface irregularities¹². This increased muscle activation improves neuromuscular coordination, enhances postural stability, and strengthens the lower extremities, all of which contribute to better balance⁶.

4. Improved Sensorimotor Integration

Balance requires the integration of vestibular, somatosensory, and visual inputs. Walking on grass challenges the somatosensory system, requiring the brain to process and integrate multiple sensory signals to maintain stability¹⁰. Over time, this sensory adaptation improves the efficiency of sensorimotor pathways, leading to better postural control and coordination⁴. Stroke survivors, who often exhibit sensory deficits, may particularly benefit from such adaptive mechanisms, as they help compensate for impaired sensory processing.

5. Increased Ankle and Foot Stability

The uneven nature of grass requires frequent ankle adjustments to maintain balance. This leads to improved ankle proprioception and stability, which are critical for both static and dynamic balance¹³. Stronger and more responsive ankle stabilizers help reduce postural sway and improve weight-shifting ability, making it easier to maintain a steady stance.

Methodology:

Study Design

Quasi-experimental pretest-posttest design to evaluate the effectiveness of walking on a grass surface in improving the static balance of subjects with chronic stroke.

Participants

Inclusion Criteria:

- Individuals diagnosed with **chronic stroke (≥6 months post-stroke)**.
- Age: **40-75 years**.
- Ability to stand and walk **with or without assistive devices**.
- No significant cognitive impairments (a minimum of 24 or above on the Mini-Mental State Exam).
- No orthopedic conditions affecting balance.

Exclusion Criteria:

- Presence of uncontrolled medical conditions (e.g., severe hypertension, cardiovascular disease).
- Visual or vestibular impairments affecting balance.
- Use of medications that significantly alter balance.

Sample Size & Sampling Technique

A **convenient sampling** method was used to recruit **30 participants** from rehabilitation centers and hospitals. From the sample, two groups were created:

- **Experimental Group (n=15):** Received grass-walking intervention.
- **Control Group (n=15):** Engaged in usual rehabilitation exercises without grass walking.

Measures of Outcome:

A. Berg Balance Scale (BBS)

For assessing both dynamic and static balance, the 14-item BBS scale is employed. With a maximum score of 56, each task is given a score between 0 and 4. Score from **41–56 indicates good balance, 21–40 suggests moderate impairment, and 0–20 signifies severe balance impairment**¹⁴.

B. One-Leg Stand Test (OLST)

By measuring how long a person can stand on one leg, the OLST evaluates postural stability. Participants will be instructed to keep their hands on their hips while raising one foot off the ground. The test will be conducted for **both legs**, with a maximum time of **30 seconds per trial**¹⁵.

Procedure

1. Pre-Assessment (Baseline Data Collection)

Participants had undergone a **pre-intervention balance assessment** using the **BBS** and **OLST** in a clinical setting. Three OLST trials were recorded, and the best time was used for analysis.

2. Intervention (Grass-Walking Training Protocol)

The experimental group participated in a **4-week intervention** with supervised **grass-walking sessions (30 minutes, 5 days/week)** in an outdoor rehabilitation area along with usual rehabilitation exercises.

- **Week 1-2:** Slow walking on grass with assistance if needed.
- **Week 3-4:** Progression to independent walking with balance-challenging tasks (e.g., heel-to-toe walking, changing directions).
- The control group received their **usual rehabilitation exercises** without grass-walking.

3. Post-Assessment

At the end of **4 weeks**, participants were reassessed using **BBS** and **OLST** to measure balance improvements.

Result:

An analysis and interpretation were conducted on the data obtained from 30 subjects diagnosed with Chronic stroke.

	Age Group A	Age Group B
Mean	56.0000	56.4000
N	15	15
Std. Deviation	5.80640	4.96847

The table 1 represents the **mean age, sample size (N), and standard deviation (SD)** for two groups: **A** and **B**. The **mean age of group A is 56.00 years**, while for **group B**, it is **56.40 years**. The difference in mean values (**0.40 years**) is minimal, suggesting that both groups have similar average ages.

Both groups have an equal number of participants (**N = 15**), ensuring balanced comparisons and reducing sampling bias.

The standard deviation of **Group A** is **5.81**, and for **Group B**, it is **4.97**. Standard deviation reflects how much individual ages deviate from the mean. **Group A** has a slightly higher SD, indicating that the age distribution in this group is more spread out compared to **Group B**. However, the similarity in standard deviations suggests that both groups have comparable age distributions, reducing potential bias in studies requiring age-matched participants.

Table 2 Mean & Standard Deviation

	Duration Group A	Duration Group B
Mean	7.8667	7.9333
N	15	15
Std. Deviation	2.82506	2.91466

The table 2 represents the mean, standard deviation, and post-stroke duration for Groups A and B. The **mean post stroke duration of group A is 7.87 months**, while for **group B**, it is **7.93 months**. The difference in mean values (**0.07 months**) is minimal, suggesting that both groups have similar average post stroke duration.

The standard deviation of **Group A** is **2.83**, and for **Group B**, it is **2.91**. Standard deviation reflects how much individual post stroke duration deviate from the mean. Since the SD values are close to each other, it suggests that the variation in duration within each group is similar. Group B has a slightly higher SD, meaning the spread of

duration values is marginally larger compared to Group A. However, this difference is minor and does not indicate a significant variation in data dispersion.

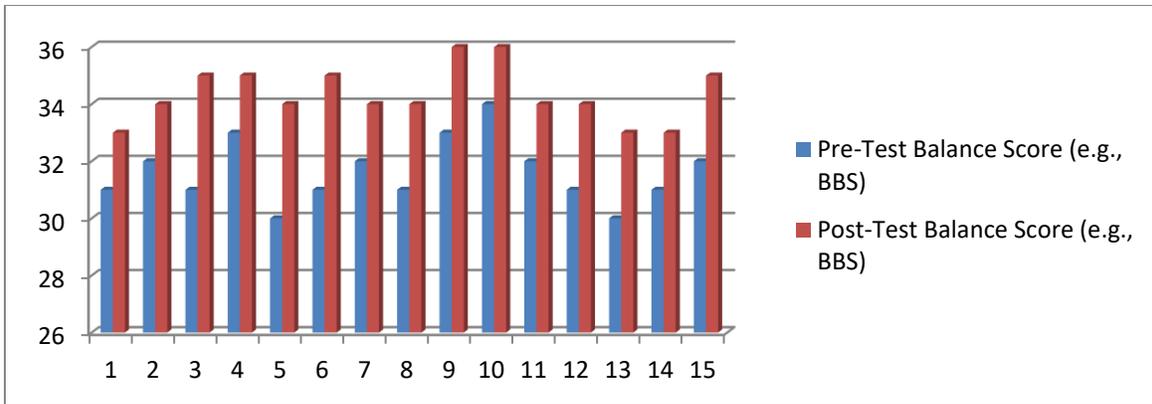
Group A- Berg Balance Scale

Table 3: Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Test A	31.6000	15	1.12122	.28950
	Post Test A	34.3333	15	.97590	.25198

In the above table, paired sample statistics are used to analyse Group A's pre and post-test results. It is clear that performance has improved because the post-test mean (34.33) is higher than the pre-test mean(31.60). The standard deviation variation in post-test scores (SD = 0.98) is slightly lower than in pre-test scores (SD = 1.12), indicating more consistent performance following the intervention. The smaller Std. Error Mean (SEM) values reveals that the sample means are stable and reliable estimates of the population mean.

Table-4: Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
Pair	PreTest A - PostTest A	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1		-2.7333	.79881	.20625	-3.17570	-2.29097	-13.252	14	.000

The intra-group analyses in the table above shows the results of the pre- and post-tests between Group A's. The Pre- and Post-test mean differences are -2.73. The standard deviations before and after the test are 0.80 apart. The standard error mean difference is 0.206. The difference's 95% confidence interval has a maximum value of -2.3 and a minimum value of -3.17.



Graph 1: Group A's balance score before and after the test on Berg Balance Scale.

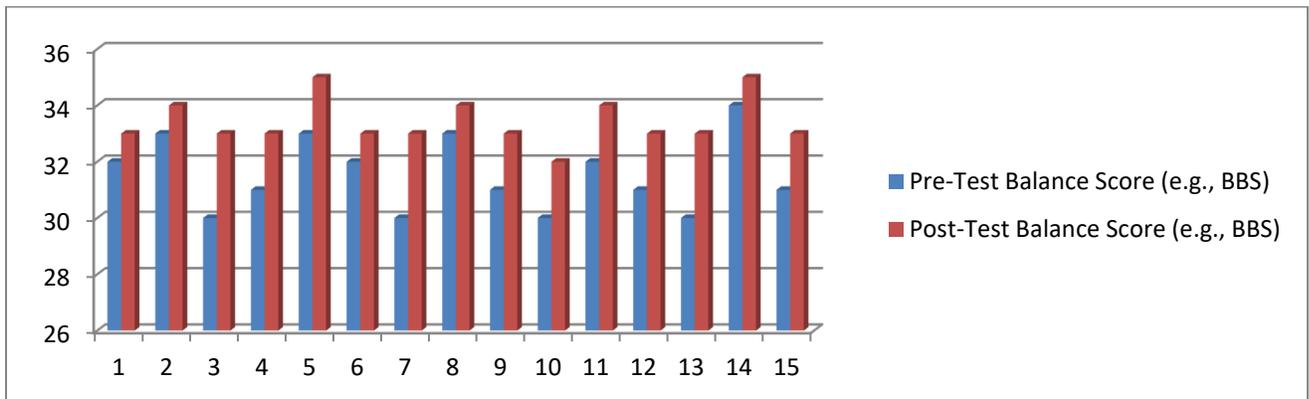
Group B: Berg Balance Scale

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTestB	31.5333	15	1.30201	.33618
	PostTest B	33.4000	15	.82808	.21381

To analyse data, the paired sample test is utilized for Group B's pre and post-test results, as shown in the above table. Compared to the pre-test means (31.53), the post-test mean (33.4) is higher, suggesting an improvement in performance. The standard deviation variation in post-test scores (SD = 0.83) is lower than in pre-test scores (SD = 1.3), indicating more consistent performance following the intervention. The smaller Std. Error Mean (SEM) values indicate that the sample means are stable and reliable estimates of the population mean.

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PreTest B - PostTest B	-1.86667	.74322	.19190	-2.27825	-1.45508	-9.727	14	.000

Group B's intra-group analyses between test results before and after are displayed in the table. Mean difference between the pre- and post-tests is -1.86. The distinction between the post and the pre-test is 0.74 standard deviations. The standard error mean difference is 0.191. The lower value of the 95% CI for the difference is -2.28, while the upper value is -1.45.



Graph 2: Group B's balance score before and after, on Berg Balance Scale.

Group A- One Leg Stand Test

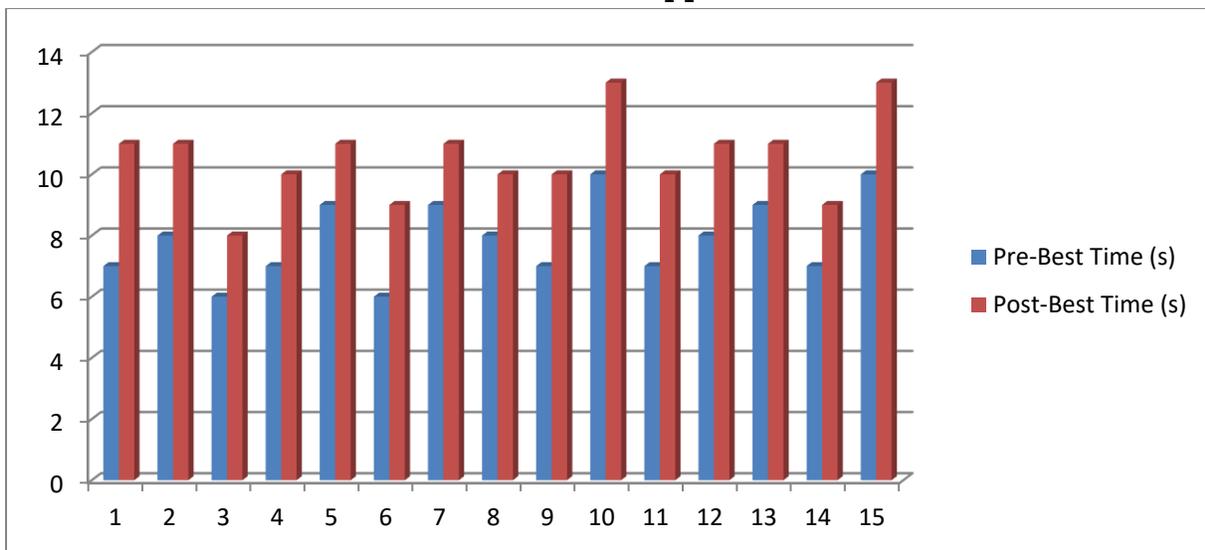
Table 7: Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTestA	7.8667	15	1.30201	.33618
	PostTest A	10.5333	15	1.35576	.35006

Results for Group A's pre and post-test are displayed in the above table. As demonstrated by the increase in mean score from 7.87 seconds in the pre-test to 10.53 seconds in the post-test, the intervention was effective. The pre and post-test standard deviation values (1.30 and 1.36, respectively) indicate comparable levels of variability in the data. The pre and post-test standard error values (0.336 and 0.350, respectively) show that the sample means are accurate representations of the population mean.

Table 8: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PreTestA - PostTestA	-2.66667	.61721	.15936	-3.00847	-2.32487	-16.733	14	.000

The intra-group analyses between Group A's pre- and post-test results are displayed in the above table. The Pre and Post-test mean differences are -2.67. The pre and post-test std. deviations differ by 0.61. The standard error mean difference is 0.16. The 95% CI for the difference is -2.32 at the upper end and -3.00 at the lower end.



Graph 3: Group A's pre- and post-test results on One Leg Stand Test.

Group B: One Leg Stand Test.

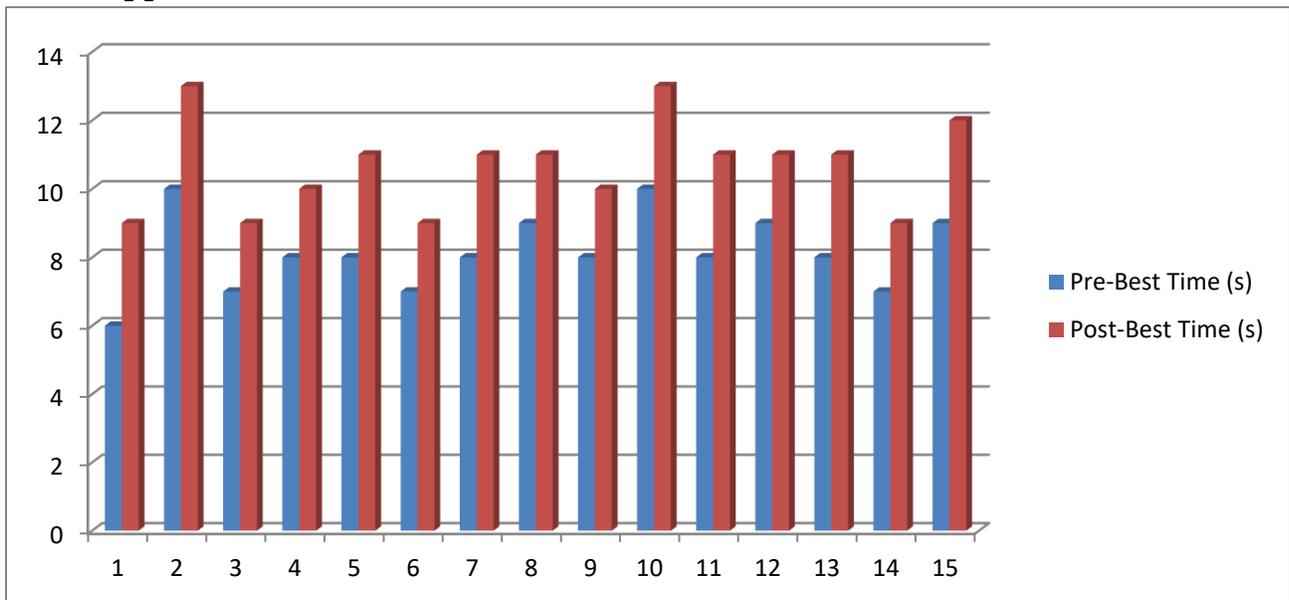
Table 9: Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTestB	8.1333	15	1.12546	.29059
	PostTest B	10.6667	15	1.34519	.34733

The One Leg Stand Test results for Group B, where the same subjects were tested before and after an intervention, are shown in the above table. The mean score increased from 8.13 seconds in the pre-test to 10.67 seconds in the post-test after the intervention. The standard deviation showed a slight increase in data variability, rising from 1.13 in the pre-test to 1.35 in the post-test. The sample means are comparatively stable and dependable, according to the standard error values (0.291 for the pre-test and 0.347 for the post-test).

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PreTestB - PostTestB	-2.53333	.51640	.13333	-2.81930	-2.24736	-19.000	14	.000

Table above displays the intra-group analyses between Group B's pre and post-test results on One Leg Stand Test. The difference in means between the Pre- and the Post-test is -2.53. The difference in standard deviation among pre and post-test is 0.52. The difference in std. error mean is 0.13. The difference's 95% confidence interval has an upper value of -2.247 and a lower value of -2.82.



Graph 4: Group B's pre- and post-test results on the One Leg Stand Test.

Table 11: Independent ‘t’ test BBS	
Group A & B – BBS	
t - value	3.0
p - value	.002

A difference between two independent groups that is statistically significant is determined by comparing their means using an independent t-test. The greater the disparity between the two groups, the higher the t-value. Thus, a t-value of 3.0 indicates a moderate to strong disparity between the mean **BBS scores**. The p-value is **less than 0.05**, (0.002) proving that the groups' differences are statistically significant.

Table 12: Independent ‘t’ test	
Group A & B – One leg stand test	
t - value	0.64
p - value	0.26

In this case, the test was conducted to evaluate the difference in **One-Leg Stand Test** performance between **Group A (Intervention group)** and **Group B (Control group)**. A t-value of 0.64 suggests that the difference is relatively small between Groups A and B in the One-Leg Stand Test. A p-value greater than 0.05 (in this case, 0.26) means Between Groups A and B, there was no appreciable statistically significant difference. The results imply that any variation in performance between the two groups is likely due to random chance rather than a true underlying effect.

Discussion:

The results of this investigation indicate that “walking on a grass surface is an effective intervention for improving static balance in individuals with chronic stroke”. The results demonstrated significant improvements in the Berg Balance Scale (BBS) and One-Leg Stand Test (OLST) scores for participants who engaged in grass walking compared to those who followed conventional rehabilitation exercises alone. The uneven nature of grass walking likely contributed to enhanced proprioception, postural reflex activation, and neuromuscular control, leading to improved balance outcomes^{8,9}.

The greater improvements in BBS scores in the experimental group suggest that walking on grass helps in postural stability and weight-shifting ability. These results concur with earlier research highlighting the significance of variable terrain walking

in enhancing balance control⁶. Additionally, improvements observed in the OLSST indicate that grass walking positively influences single-leg stance control, which is crucial for everyday activities like stepping and changing directions¹¹.

Interestingly, while both groups exhibited balance improvements. The experimental group's post-test results improved more dramatically. It implies that incorporating grass walking as a rehabilitation strategy may be superior to conventional exercises alone. The natural surface's sensory stimulation and postural challenges may be key contributors to this effect. Given that stroke survivors often struggle with impaired sensory feedback and postural instability, this intervention may provide an accessible and cost-effective rehabilitation approach.

Conclusion:

This study concludes that “walking on a grass surface is an effective intervention for improving static balance in individuals with chronic stroke”. The results indicate that training on an uneven surface such as grass leads to greater improvements in balance performance compared to standard rehabilitation exercises alone. Enhanced proprioceptive input, neuromuscular activation, and postural adjustments induced by grass walking may contribute to these benefits. Given its feasibility and accessibility, incorporating grass walking into rehabilitation programs could provide a practical strategy to enhance postural stability and reduce fall risks in stroke survivors.

Limitations:

This research has several limitations in spite of the encouraging results. First of all, the results may not be as broadly applicable as they may be because of the small sample size. A larger sample could provide more robust evidence of the intervention's effectiveness. Second, the study only lasted four weeks, and it is unknown how walking on grass may affect balance maintenance in the long run. Future research should explore whether continued practice leads to sustained improvements. Additionally, external factors such as weather conditions and surface variability may have influenced the participants' performance, introducing potential variability in the results. Finally, the study did not assess dynamic balance extensively, which could provide further insights into the broader functional benefits of grass walking.

Future Recommendations:

Future studies should aim to address the limitations of this research by using longer follow-up times and bigger sample numbers to evaluate the enduring effects of grass walking on balance. Investigating the impact of different surface textures (e.g., sand, gravel) could also help determine whether similar benefits can be observed with

other natural terrains. Additionally, future research should incorporate dynamic balance assessments and gait analysis to comprehensively evaluate the functional outcomes of this intervention. Finally, exploring the integration of grass walking with other balance training methods, such as virtual reality or sensory integration exercises, could further enhance stroke rehabilitation strategies.

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