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RESEARCH ARTICLE

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The effect of trunk exercises with hip strategy training to maximize independence level and balance for patient with stroke: Randomized controlled study

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Abstract

Background: Balance while seated and the capacity to conduct selective trunk movements are significant predictors of functional outcomes following stroke. Patients with inappropriate muscle activation and inadequate movement control in the trunk muscles cause mobility and daily function difficulties. Stroke patients have weak leg muscles and decreased balance, resulting in compensatory changes. Functional postural strategy training is necessary to restore balance in these patients. Few studies have examined the effect of physical therapy trunk exercises with hip strategy training on improving balance and increasing independence after stroke.

Purpose: This study aimed to explore the effect of selective trunk exercises (STE) with hip strategy training in improving balance in patients with stroke as well as independence levels.

Method: A multicenter inpatient stroke treatment randomized pre- and post-test control trial. Forty-six stroke survivors were randomly allocated to experimental or control groups (n = 23 each). The experimental group received hip strategy training and trunk exercises. All groups received Neuro-Developmental Treatment (NDT)-based physical therapy four times a week for 6 weeks. Trunk impairment scale, Berg Balance Scale (BBS), and functional independence measure (FIM) measured static and dynamic seated balance, functional balance, and trunk movement coordination pre- and post-therapy.

Results: The experimental group's post-therapeutic measures were substantially higher than the control group. The experimental group's TIS score, and subscale improved more than the control group. The experimental group considerably increased the BBS score. The experimental group also showed greater FIM gains.

Conclusions: This study demonstrated that adding STE in conjunction with hip strategy training to patients after has a positive impact on trunk control while maintaining static and dynamic sitting balance, functional balance, and independence levels which are effective in stroke rehabilitation.

KEYWORDS
balance, functional independence, hip strategy, rehabilitation, stroke, trunk

1 | INTRODUCTION

Stroke is a prevalent health illness that impairs sensory and motor function as well as intellectual processing (Feigin et al., 2017). Stroke patients are also more likely to fall than the general elderly population, which puts them at a higher risk of subsequent impairment, hospitalization, and fatality (Scuffham et al., 2003). Although disability and falling are multifaceted problems, decreased balancing ability is a prevalent and crucial underlying component (Kwakkel et al., 1996; Lamb et al., 2003). Stroke patients have a "limit of stability," which is the farthest they can shift their gravitational center without losing their equilibrium (Geiger et al., 2001). Those with hemiplegia may be unable to shift their center of gravity as far in any direction before losing their balance, a measure known as their "limits of stability" (Geiger et al., 2001). Balance disorders have been found to affect 17%–83% of people who have had a stroke (Tyson et al., 2006; Vincent-Onabajo et al., 2018) and can appear in many ways. After a stroke, there is more postural sway while sitting or standing, as well as a reduced range of movement for the body's center of mass (COM; de Haart et al., 2004; van Dijk et al., 2017).

Despite this, motor control of the trunk is impaired in people who have had a stroke, particularly in the frontal plane. They cannot keep their weight equally distributed between their feet because of trunk muscle weakness and loss of trunk motor control (Chou et al., 2003; de Haart et al., 2004). Most physical functions require sufficient balance to be performed. Trunk control is essential to maintain a body position, to remain steady when changing positions, to execute daily activities, and to perform motion (Bohannon & Walsh, 1992). In turn, weight shifting requires selective trunk motions, and maintaining an upright stance requires keeping one's center of gravity within their supporting structure (Ryerson et al., 2008). Following a stroke, patients experience spasticity, cognitive dysfunction, decreased balance (Tyson et al., 2006; Weerdesteyn et al., 2008), sensorimotor deficits (Oliveira et al., 2011), as well as diminished strength in trunk muscles (Dickstein et al., 2004; Tanaka et al., 1998). Kim et al. reported that in stroke patients, trunk muscle activation during a reaching task is highly correlated with both trunk control and balance (Kim et al., 2017). On the other hand, during standing, weight shifting, and sustaining static and dynamic postures, the trunk muscles are involved in selected motions to maintain the center of gravity as the basis of support (Verheyden et al., 2004). These effects can make living independently difficult (Shumway-Cook et al., 2007). Thus, it would seem sensible that trunk exercises might enhance functional recovery and balance. Evidence demonstrates that trunk exercises performed while sitting or lying supine, involving core stability, reaching and weight shift exercises, and proprioceptive neuromuscular facilitation, may enhance trunk control, sitting and standing balance, and mobility for stroke patients in the subacute stage (6 months after onset; Cabanas-Valdes et al., 2013; Haruyama et al., 2017; Yoon et al., 2020).

Patients with ischemic and hemorrhagic strokes must restore balance in order to regain mobility in everyday activities. In illustration, muscle weakness in the legs makes balance control challenging, indicating improper movement strategies (Hendrickson et al., 2014). Postural strategy exercises have been utilized to restore balance in stroke patients. Stroke patients adopt the step method or other compensating strategies to grab a wall or object because they are unable to use the ankle strategy due to the reduction of the surface's base. While the hip strategy is necessary to establish a base of support and prevent falls, the ankle strategy is needed to maintain balance (Mok et al., 2004; Nagy et al., 2007).

Following this line of thinking, the hip strategy is used when ankle control is impossible and involves the contraction of the hip and trunk muscles. Increased amplitude and altered timing of early and anticipatory postural adjustments have been shown by arm-reaching training utilizing the trunk and hip (Hatzitaki et al., 2009; Saito et al., 2014).

In spite of the existing information, there are still knowledge gaps limiting our understanding.

In previous studies, reaching exercise with the hips and trunk helped to engage different muscles and sustain balance more effectively by providing the central nervous system with a range of sensory inputs for successful interactions between the body and environment (Hatzitaki et al., 2009; Hendrickson et al., 2014). Moreover, ankle and hip strategy training enhanced the forward, backward, paretic, and non-paretic side areas in stroke patients. Furthermore, ankle and hip strategy training was more beneficial for center-of-pressure movement compared to ankle strategy training (Park et al., 2019). To date, research has not yet determined the effect of trunk exercise with hip strategy training and the extent of its impact on balance and independence. Filling these knowledge gaps could provide information for the planning of balance training and increase independence levels in stroke rehabilitation.

Given the importance of balance in the hip strategy, this study aimed to investigate the effects of trunk exercises with hip strategy training to improve balance. Additionally, this study aimed to determine whether combining trunk exercises and hip strategy training might also positively affect independence level.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

This was a randomized controlled study that was conducted in Sultan Bin Abdulaziz Humanitarian City and King Saud Medical City. The study included patients aged 28–86 years with hemorrhagic or ischemic stroke diagnosis with a duration since diagnosis of less than 6 months. Patients included in that study should be able to walk 10 m independently with a mini-mental state exam (MMSE) score of more than 24 and a score of less than 21 on the TIS. Patients with neurological and orthopedic disorders, patients with cognitive impairments, and patients with visual impairments and visual field defects were excluded.

3 | DATA COLLECTION

Each subject's data input page included demographic data. For screening, the MMSE, motor assessment scale, and trunk impairment scale (TIS) were used, and for treatment decision-making, the TIS, Functional independence measure (FIM), and Berg Balance Scale (BBS) were used before and after treatment.

3.1 | Instruments

The BBS scores 14 tasks from 0 to 4 based on patient performance. All tasks have 56 points, with 0–20 being a bad balance and 40–56 being a good balance. TIS measures trunk motor deficits following stroke. The TIS scores static and dynamic sitting balance and trunk movement coordination ranged from 0 to 23, with higher scores indicating superior trunk performance. Static sitting balance tests if a patient can sit with both feet on the floor and legs crossed. The patient must also pass the nonaffected leg over the hemiplegic limb while maintaining trunk stability. The dynamic seated balance subscale measures upper and lower trunk lateral flexion. The purpose of the FIM scale is to evaluate and rank the functional status of a person according to the amount of support that person needs.

3.2 | Procedure

To compare, two groups were chosen as shown in Figure 1. Twenty three control and 23 research group members. Both groups received 30-min, four-times-a-week conventional therapy for six weeks. Stretching, strengthening lower extremity muscles, maintaining balance, carrying, and walking more were part of this treatment. The experimental group completed more selective trunk exercises and hip strategy training. Selective upper and lower trunk motions in supine and seated patients included flexion rotation, unilateral pelvic bridge, and pelvic raising. They also completed crook-lying selective flexion-extension of the lower trunk, upper and lower trunk lateral flexion and rotation, and shoulder height forward and lateral reach. Changes in standing duration and base of support made training harder. On solid and unstable surfaces, hip strategy exercises moved the hips and trunk. The solid platform exercise included standing on one leg on the non-paralyzed side for 10 s and then on both legs for 5 s. The uneven floor exercise utilizes the AIREX Balance Pad.

4 | STATISTICAL ANALYSIS

SPSS 23 software was used for data analysis. Descriptive statistics were used to describe and summarize personal data (age, gender, associated diabetes or hypertension, and stroke-related questions like type of stroke, affected site, and onset time). Measures of central tendency (mean, median, mode) and measures of variability (range, variance, standard deviation) were applied to those variables. The Kolmogorov-Smirnov Test and visual inspection of the data were performed to evaluate whether the data were normally distributed. Differences between the experimental and control groups for the results of the TIS pre and post, FIM instrument pre and post, and Berg balance tests pre and post were evaluated using repeated measures (ANOVA). The level of significance was set to be at $p < 0.05$.

4.1 | Ethical considerations

The study was approved by the institutional review board at Sultan bin Abdulaziz Humanitarian City, IRB No# 77-2022-IRB and King Saud Medical City with IRB No# H1E-22-Apr22-01. It was compiled following the Declaration of Helsinki, the International Conference on Harmonization of Good Clinical Practice, and the local regulations for clinical research. All the study participants signed the informed consent form.

5 | RESULTS/FINDINGS

A total of 46 patients with hemiparetic stroke were recruited for this study. The study sample will be two groups: control who are receiving conventional treatment and intervention groups in a ratio of 1 case to 1 control. The control group was 78.3% male. The intervention group genders were equal. The intervention group had greater primary (34.8%) and secondary (30.4%) education than the control group (34.8%). The control group had four-stroke months, whereas the intervention group had three. Hypertension was greater in the intervention group (82.6% vs. 65.2%). Both had diabetes. Ischemic stroke was common in both groups. Strokes occurred in both groups. The intervention group had 60.9% right hemiplegia, whereas the control group had 56.5% (Table 1).

Table 2 presents the mean difference between the control and intervention groups and reveals that there is no significance in terms of TIS and its subscales before intervention; however, BBS and FIM showed a significant difference ($p > 0.05$). In terms of TIS, BBS, and FIM and its subscales, the post-intervention mean difference between the control and intervention groups was statistically significant (p.001; Table 2). However, after the intervention, the mean score of the intervention group on BBS, FIM, and TIS, as well as its subscales TIS Static, TIS Dynamic, and TIS Coordination, increased significantly in comparison to the control group, indicating the intervention's effectiveness.

Table 3 presents the between group comparison, which demonstrates that the average score on the BBS, FIM, and TIS scales as well as the TIS subscales comprising TIS Static, TIS Dynamic, and TIS Coordination was significantly higher in the intervention group compared to the control group (*p*. 001). As a result of this, the data revealed the efficacy of the intervention regarding BBS, FIM, and TIS as well as its subscales.

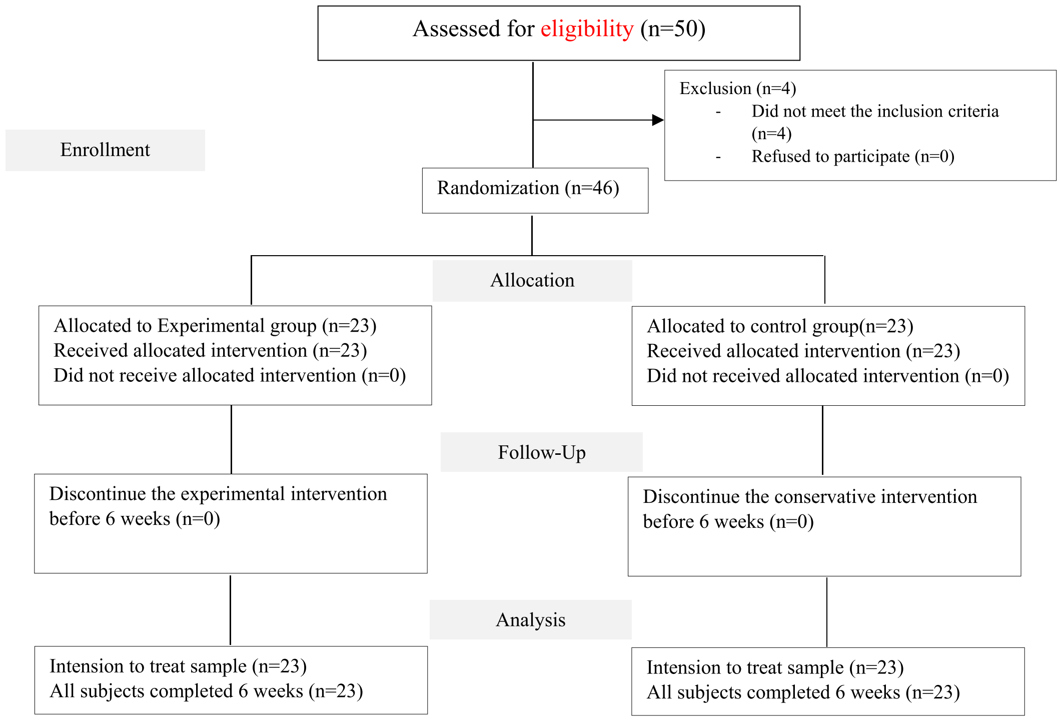

FIGURE 1 Study flowchart.

Table 4 shows the post-intervention outcomes of the TIS scores according to the patient's sociodemographic characteristics and medical history. The total score and the subdomains scores were significantly higher among the intervention group compared with the control group regardless of gender, site of the stroke, and affected side of the body. Same was observed with FIM and BBS scores as shown in Table 5.

Table 6 shows the Post Hoc and Effect size differences in Control-Intervention. The Cohen's d value was 1.73 for the total TIS score, 4.42 for post BBS scores, and 1.73 for post FIM scores.

6 | DISCUSSION

Restoring and developing patients' balance and independence to carry out their basic daily activities after a stroke is one of the most important goals of post-stroke rehabilitation. The purpose of the study was to find evidence of the benefits of trunk exercises combined with hip strategy training for stroke patients, with the ultimate objective of maximizing the patients' levels of independence while also improving their balance, as compared to the control group. A statistically significant impact was found on both levels of independence and balance. These findings indicated that the experimental training could further improve trunk control, balance, and independence.

Despite improving functionally, stroke patients frequently acquire and use unhelpful compensatory tactics, which reduce trunk control (Verheyden et al., 2009). When a seated individual extends one arm, the center of gravity rises forward, and the body rotates rearward to maintain stability (De Luca et al., 2020). This center of gravity change and reaction force cause postural swing (Cho et al., 2014). The neurological system also needs well-coordinated and controlled muscular activity to adjust for weight shifting's COM change (Singh et al., 2018).

The purpose of the study was to find evidence of the benefits of trunk exercises combined with hip strategy training for stroke patients, with the ultimate objective of maximizing the patients' levels of independence while also improving their balance, as compared to the control group. In our study, we intended to combine trunk exercises with hip strategy training. We hypothesized that this combination of exercises would specifically strengthen the muscles and rehabilitate the patient, leading to improvements in the patient's static and dynamic balance while sitting and standing, as well as an increase in the patient's level of independence and a greater degree of independence for the patient. When compared to the regular exercises, the addition of these workouts resulted in substantial improvements in terms of balance, control, and degree of independence.

In the current study, the trunk exercises assisted the paralyzed side in moving and bearing weight again by increasing the trunk's flexion, extension, lateral flexion, and rotation. They also helped in improving proprioception. The movements of the trunk and limbs had an effect, in both FIM and BBS, on the location of the center of gravity as well as the sitting and standing motions.

Strengthening and stabilizing the muscles in the trunk requires exercise. Patients who have had a stroke may have asymmetrical movements and pelvic motions that are unstable (Dubey et al., 2018). The trunk is the primary pivot point of the body and distal limb

TABLE 1 Sociodemographic and clinical characteristics of the study population.

Variable	Category	Control group *N* (%)	Intervention group *N*	*p*-value
Gender	Female	5 (21.7)	12 (52.2)	0.032
	Male	18 (78.3)	11(47.8)	
	Total	23 (100.0)	23 (100.0)	
Education	Bachelor	3 (13.0)	2 (8.7)	0.362
	Lower secondary	8 (34.8)	3 (13.0)	
	Post-secondary	3 (13.0)	7 (30.4)	
	Primary	7 (30.4)	8 (34.8)	
	Upper secondary	2 (8.7)	3(13.0)	
	Total	23 (100.0)	23 (100.0)	
Duration of stroke	3 Months	4 (17.4)	11(47.8)	0.146
	4 Months	12 (52.2)	6 (26.1)	
	5 Months	5 (21.7)	4 (17.4)	
	6 Months	2 (8.7)	2 (8.7)	
	Total	23 (100.0)	23(100.0)	
Hypertension	No	8 (34.8)	4 (17.4)	0.179
	Yes	15 (65.2)	19 (82.6)	
	Total	23 (100.0)	23 (100.0)	
Diabetes mellitus	No	8 (34.8)	9 (39.1)	0.760
	Yes	15 (65.2)	14 (60.9)	
	Total	23 (100.0)	23(100.0)	
Stroke type	Hemorrhagic	6 (26.1)	7 (30.4)	0.743
	Ischemic	17 (73.9)	16 (69.6)	
	Total	23 (100.0)	23 (100.0)	
Site of stroke	Left	10 (43.5)	11(47.8)	0.767
	Right	13 (56.5)	12 (52.2)	
	Total	23 (100.0)	23 (100.0)	
Affected side	Left hemiplegia	13(56.5)	9 (39.1)	0.238
	Right hemiplegia	10 (43.5)	14 (60.9)	
	Total	23(100.0)	23 (100.0)	

TABLE 2 Mean difference between control and intervention groups in terms of pre and post-TIS & its subscales, BBS, and FIM (Within group).

	Control (23)				Intervention (23)			
Variables	Before Mean (SD)	After Mean (SD)	Mean difference (95% CI)	*p*-value	Before Mean (SD)	After Mean (SD)	Mean difference (95% CI)	*p*-value
TIS-S	4.57 (0.73)	6.35 (0.71)	1.78 (1.34–2.21)	**<0.001**	5.00 (1.09)	6.83 (0.39)	1.83 (1.33–2.32)	**<0.001**
TIS-D	5.83 (1.19)	6.87 (1.01)	1.04 (0.36–1.71)	**0.003**	6.04 (1.11)	8.57 (1.12)	2.53 (1.85–3.20)	**<0.001**
TIS-C	2.04 (1.40)	2.61 (0.99)	0.57 (−0.16–1.30)	0.126	2.39 (1.59)	3.65 (0.57)	1.26 (0.53–1.98)	**0.001**
TIS-total	12.5 (2.59)	17.6 (1.75)	5.10 (3.75–6.44)	**<0.001**	13.4 (2.90)	21.7 (1.30)	8.30 (6.93–9.66)	**<0.001**
BBS	36.1 (1.79)	39.6 (1.67)	3.50 (2.44–4.55)	**<0.001**	37.5 (1.24)	46.3 (1.39)	8.80 (7.99–9.60)	**<0.001**
Total FIM	76.9 (18.54)	82.7 (17.37)	5.80 (−5.13–16.73)	0.290	84.8 (11.80)	107.1(10.67)	22.3 (15.45–29.14)	**<0.001**

Note: Bold values indicate statistical significance.

Abbreviations: BBS, berg balance scale; FIM, functional independence measure; TIS, trunk impairment scale.

TABLE 3 Between group comparison.

	Before				After			
Variables	Control Mean (SD)	Intervention Mean (SD)	Mean difference (95% CI)	*p*-value	Control Mean (SD)	Intervention Mean (SD)	Mean difference (95% CI)	*p*-value
TIS-S	4.57 (0.73)	5.00 (1.09)	0.43 (−0.13–0.99)	0.118	6.35 (0.71)	6.83 (0.39)	0.48 (0.13–0.82)	**0.007**
TIS-D	5.83 (1.19)	6.04 (1.11)	0.21 (−0.473–0.89)	0.525	6.87 (1.01)	8.57 (1.12)	1.70 (1.06–2.33)	**<0.001**
TIS-C	2.04 (1.40)	2.39 (1.59)	0.35 (−0.54–1.24)	0.435	2.61 (0.99)	3.65 (0.57)	1.40 (0.55–1.52)	**<0.001**
TIS-total	12.5 (2.59)	13.4 (2.90)	0.90 (−0.73–2.53)	0.267	17.6 (1.75)	21.7 (1.30)	4.10 (3.18–5.01)	**<0.001**
BBS	36.1 (1.79)	37.5 (1.24)	1.40 (0.48–2.31)	**0.003**	39.6 (1.67)	46.3 (1.39)	6.70 (5.81–7.58)	**<0.001**
Total FIM	76.9 (18.54)	84.8 (11.80)	7.90 (−1.33–17.13)	0.091	82.7 (17.37)	107.1(10.67)	24.4 (15.83–32.96)	**<0.001**

Note: Bold values indicate statistical significance.

Abbreviations: BBS, berg balance scale; FIM, functional independence measure; TIS, trunk impairment scale.

movement cannot occur without the proximal trunk maintaining its stability. Therefore, the enhancement of proximal trunk control affects functional tasks such as standing and walking (Lee, 2021).

In the present investigation, trunk exercises were performed according to a protocol developed by Karthik Babu et al. (Karthikbabu et al., 2011b). Multiple studies indicate that subacute stroke patients whose trunk control improved after receiving an additional 10 h of task-specific training on the trunk support this viewpoint. Stroke patients' correct trunk posture enhanced their weight distribution while seated in the early stages of the disease (Cabanas-Valdés et al., 2021; Khallaf, 2020).

Maintaining the trunk is important for effective support of the spine and hips, improvement of stability during movement, muscle development, changing the way muscles move, and maintaining balance (Richardson et al., 2002). Previous research indicated that physio ball exercises improve trunk lateral flexion and rotation, as judged by the TIS's dynamic sitting balance and coordination subscales, better than plinth exercises (Drysdale et al., 2004). As part of our efforts to teach the patient hip strategy, we performed particular trunk movements while they stood on an unstable surface. This is considered a combination of more than one rehabilitation application for the patient. According to the findings of our research, the unilateral bridging exercise, which was one of the exercises that were performed throughout our study, is fantastic for weight bearing and balance, as has been reported previously (Song & Heo, 2015).

This study looked at the weight-bearing and weight-shifting capabilities of the side that was affected by the condition. All three groups were able to increase their maximum weight bearing capacity to between 46.21.44 and 47.01.33 pounds. SBG 1020.6210.1 had a smaller COM shifting impact on the AL and PL directions compared to UBG 689.5269.7 which exhibited a larger impact. UBG possesses the highest body weight bearing capacities as well as the greatest PL and AL COM shifting abilities. The balancing exercise that the UBG group did was judged to be the most effective. In a great number of the earlier studies, bridging exercises were either included or modified.

TIS was primarily utilized as an outcome measure in past studies investigating the impact of trunk exercise on sitting balance in individuals in the subacute stage of stroke, and the results consistently showed that trunk exercises resulted in considerably higher TIS total scores than sham or control training (Cabanas-Valdés et al., 2016; Dean et al., 1999; Saeys et al., 2012; Yoon et al., 2020). In the present investigation the intervention group was compared to the control group using the TIS dynamic, the intervention group exhibited a substantial improvement in terms of the TIS dynamic.

This agreed with the findings of the research that was conducted by Kim et al. (2017). More recent attention has focused on the importance of trunk exercises in post-stroke patients. In a recent cross-sectional investigation, it was discovered that poor trunk control and lower extremity recovery are connected to pelvic instability in chronic stroke patients (Karthikbabu et al., 2011b). Moreover, when standing, pelvic stability, postural stability, and load transmission to the lower extremities all benefit from the coordinated activity of the lower trunk and hip muscles (Grimaldi, 2011). Although the trunk is linked to the stability of the pelvis, as we mentioned previously, the patients in our current study received trunk exercises in conjunction with hip strategy training. However, the purpose of hip strategy training is to enhance trunk and hip muscle activation when standing by concentrating on the hip strategy. The first exercise based on the hip strategy, the hip and trunk movement exercise, was implemented by enhancing and adjusting the functional reach test (Wernick-Robinson et al., 1999). The functional reach test is an assessment approach that uses the hip strategy to maximize forward reach while standing, and the capacity to balance is recovered as the action is enhanced (Duncan et al., 2005). Tandem and one-leg stance exercises are required to stabilize the body in the frontal plane (Mao et al., 2006; Sozzi et al., 2013). These enhance body sway and aid in balance in a variety of circumstances. As a result, hip strategy exercises enable the body to control its center of pressure, which is an essential response for balancing (Horak et al., 1989; Horak & Nashner, 1986; Nagy et al., 2007; Winter, 1995). This result is supported by a recent study showing that ankle and hip strategy training enhanced the forward, backward, paretic, and non-paretic side areas in stroke patients. Furthermore, ankle and hip strategy training was more beneficial for center of pressure movement than just ankle strategy training (Park

TABLE 4 Post-intervention outcomes of the trunk impairment scale according to the patient sociodemographic characteristics and medical history.

		TIS-S			TIS-D			TIS-C			TIS total		
Variable	Category	Control Mean (SD)	Intervention Mean (SD)	*p*	Control Mean (SD)	Intervention Mean (SD)	*p*	Control Mean (SD)	Intervention Mean (SD)	*p*	Control Mean (SD)	Intervention Mean (SD)	*p*
Gender	Female	6.40 (0.89)	7.0 (0.0)	**0.02**	7.0 (1.41)	8.92 (1.16)	**0.01**	2.40 (0.89)	3.58 (0.67)	**<0.001**	15.80 (2.39)	19.50 (1.45)	**<0.001**
	Male	6.33 (0.69)	6.64 (0.50)	0.24	6.83 (0.92)	8.18 (0.98)	**<0.001**	2.67 (1.03)	3.72 (0.46)	**<0.001**	15.89 (2.14)	18.54 (1.57)	**<0.001**
	***p*-value**	0.90	**0.02**		0.75	0.07		0.64	0.73		0.94	0.08	
Education	Less than bachelor	6.35 (0.75)	6.86 (0.36)	**0.01**	6.80 (1.01)	8.57 (1.08)	**<0.001**	2.65 (1.04)	3.67 (0.58)	**<0.001**	15.85 (2.23)	19.10 (1.41)	**<0.001**
	Bachelor	6.33 (0.58)	6.50 (0.70)	**<0.001**	7.33 (1.15)	8.5 (2.12)	**<0.001**	2.33 (0.58)	3.5 (0.70)	**<0.001**	16.00 (1.73)	18.5 (3.53)	**<0.001**
	***p*-value**	0.97	0.22		0.41	0.22		0.62	0.93		0.91	0.70	
Duration of stroke	3–4 Months	6.38 (0.72)	6.76 (0.44)	0.07	6.94 (1.06)	8.41 (1.18)	**<0.001**	2.63 (1.02)	3.65 (0.61)	**<0.001**	16.00 (2.39)	18.82 (1.67)	**<0.001**
	5–6 Months	6.60 (0.55)	6.63 (0.74)	0.04	6.60 (1.14)	8.5 (1.19)	**<0.001**	2.60 (1.14)	3.37 (0.74)	0.03	15.80 (1.64)	18.5 (2.39)	**<0.001**
	***p*-value**	0.78	0.20		0.63	0.27		0.90	0.94		0.66	0.26	
Hypertension	Yes	6.27 (0.70)	6.84 (0.37)	0.56	6.73 (0.96)	8.53 (1.02)	0.13	2.60 (0.99)	3.74 (0.45)	0.34	15.67 (2.23)	19.16 (1.46)	0.10
	No	6.25 (0.96)	6.75 (0.46)	0.57	7.50 (1.0)	7.62(1.68)	0.12	2.75(0.96)	2.87(1.12)	0.35	16.50(2.52)	17.25(2.25)	0.11
	***p*-value**	0.46	0.67		0.38	0.90		0.95	0.12		0.54	0.45	
Diabetes mellitus	Yes	6.20 (0.77)	6.93 (0.27)	**<0.001**	6.73 (0.96)	8.71 (1.14)	**<0.001**	2.53 (0.99)	3.64 (0.50)	**<0.001**	15.53 (2.23)	19.29 (1.64)	**<0.001**
	No	6.63 (0.52)	6.67 (0.50)	0.86	7.13 (1.13)	8.33 (1.11)	0.04	2.75 (1.04)	3.66 (0.70)	0.04	16.50 (1.69)	18.66 (1.41)	0.01
	***p*-value**	0.78	0.11		0.41	0.33		0.87	0.54		0.22	0.11	
Stroke type	Hemorrhagic	6.50 (0.55)	6.86 (0.38)	0.19	7.33 (0.82)	8.43 (1.27)	0.10	2.83 (1.17)	3.86 (0.38)	0.05	16.67 (1.63)	19.14 (1.77)	0.02
	Ischemic	6.15 (0.80)	6.80 (0.41)	0.02	6.62 (0.96)	8.30(1.30)	**<0.001**	2.46 (0.97)	3.40 (0.75)	**<0.001**	15.31 (2.39)	18.50 (1.82)	**<0.001**
	***p*-value**	0.12	0.80		0.20	0.71		0.53	0.27		0.30	0.84	
Site of stroke	Left	6.10 (0.74)	6.82 (0.40)	0.01	6.70 (0.82)	8.45 (0.13)	**<0.001**	2.40 (0.97)	3.55 (0.69)	0.01	15.30 (2.31)	18.82 (1.33)	**<0.001**
	Right	6.54 (1.15)	6.83 (0.38)	0.19	7.00 (1.15)	8.66 (1.15)	0.001	2.77 (1.01)	3.75 (0.45)	0.005	16.31 (1.97)	19.25 (1.76)	**<0.001**
	***p*-value**	0.14	0.92		0.49	0.66		0.38	0.40		0.27	0.51	
Affected side	Left hemiplegia	6.54 (0.66)	6.89 (0.33)	0.16	7.00 (1.15)	9.00 (1.12)	**<0.001**	2.77 (1.01)	3.78 (0.44)	**<0.001**	16.31 (1.97)	19.67 (1.66)	**<0.001**
	Right hemiplegia	6.10 (0.74)	6.79 (0.42)	**<0.001**	6.70 (0.82)	8.28 (1.06)	**<0.001**	2.40 (0.97)	3.57 (0.64)	**<0.001**	15.30 (2.31)	18.64 (1.39)	**<0.001**
	***p*-value**	0.15	0.55		0.49	0.14		0.39	0.41		0.27	0.12	

Note: Bold values indicate statistical significance.

Abbreviation: TIS, trunk impairment scale.

TABLE 5 Post-intervention outcomes of the berg balance scale and Functional independence measure according to the patient sociodemographic characteristics and medical history.

Variable	Category	Post_BBS Control Mean (SD)	Post_BBS Intervention Mean (SD)	p-value	Post_FIM Control Mean (SD)	Post_FIM Intervention Mean (SD)	p-value
Gender	Female	39.0 (2.0)	45.75 (1.15)	**<0.001**	45.75 (1.48)	109.17 (9.55)	**<0.001**
	Male	39.78 (1.59)	46.81 (1.07)	**<0.001**	80.6 (18.34)	104.81 (11.80)	**<0.001**
	***p*-value**	0.31	0.71		0.31	0.19	
Education	Less than bachelor	39.50 (1.73)	46.29 (1.42)	**<0.001**	81.50 (17.89)	107.19 (11.03)	**<0.001**
	Bachelor	40.33 (1.15)	46.0 (1.41)	**<0.001**	90.33 (13.28)	106.0 (8.48)	**<0.001**
	***p*-value**	0.43	0.62		0.42	0.79	
Duration of stroke	3–4 Months	39.63 (1.67)	46.47 (1.33)	**<0.001**	84.69 (18.33)	108.47 (10.97)	**<0.001**
	5–6 Months	40.40 (1.34)	43.62 (3.99)	**<0.001**	80.0 (17.42)	95.62 (16.55)	**<0.001**
	***p*-value**	0.94	0.23		0.40	0.30	
Hypertension	Yes	38.73 (1.39)	46.16 (1.46)	**<0.001**	78.47 (17.48)	107.53 (10.61)	0.13
	No	41.50 (0.58)	43.87 (3.13)	**<0.001**	98.50 (0.58)	93.75 (19.12)	0.13
	***p*-value**	0.11	0.45		0.11	0.67	
Diabetes mellitus	Yes	39.13 (1.77)	45.93 (1.64)	**<0.001**	80.07 (17.65)	109.50 (10.05)	**<0.001**
	No	40.50 (1.07)	46.77 (0.66)	**<0.001**	87.50 (16.85)	103.33 (11.09)	**0.03**
	***p*-value**	0.10	0.35		0.22	0.66	
Stroke type	Hemorrhagic	39.83 (1.17)	45.86 (1.68)	<0.001	83.00 (17.47)	104.29 (9.72)	0.02
	Ischemic	39.08 (1.89)	45.35 (2.49)	**<0.001**	77.62 (17.74)	106.35 (10.68)	**<0.001**
	***p*-value**	0.56	0.81		0.96	0.42	
Site of stroke	Left	39.00 (1.41)	46.18 (1.40)	**<0.001**	71.50 (15.57)	106.27 (11.72)	**<0.001**
	Right	40.08 (1.75)	46.33 (1.45)	**<0.001**	91.23 (13.71)	107.83 (10.07)	**<0.001**
	***p*-value**	0.71	0.37		**<0.001**	0.73	
Affected side	Left hemiplegia	40.08 (1.75)	45.78 (1.20)	**<0.001**	91.23 (13.71)	108.0 (8.34)	**<0.001**
	Right hemiplegia	39.00 (1.41)	46.57 (1.45)	**<0.001**	71.50 (15.57)	106.5 (12.20)	**<0.001**
	***p*-value**	0.13	0.19		**<0.001**	0.75	

Note: Bold values indicate statistical significance.

Abbreviations: BBS, Berg balance scale; FIM, functional independence measure.

et al., 2019). Reaching exercise with the hip and trunk provides an extensive range of sensory inputs to the central nervous system, allowing for successful interactions between the body and its environment. It also aids in various muscle engagements and improves balance (Hatzitaki et al., 2009; Saito et al., 2014). Hip strategy exercise causes more muscles to contract while supporting the ground by moving the knee, ankle, trunk, and hip (Bryanton et al., 2015; Chizewski & Chiu, 2012). These movements cause varying weight shifts (Saito et al., 2014) and increasing shear forces on the feet (Maki & McIlroy, 1997).

The results of Cohen's d tests show that those who were part of the experimental group did much better than those who were part of the control group. The results of our research make it abundantly evident that there are advantages to combining certain trunk exercises with hip approach training. This result is supported by evidence that indicates training the core and hips is associated with improved balance in people of senior age (Nagy et al., 2007).

We found that participating in hip strategy exercise led to an increase in a measure of independence known as FIM as compared to levels that existed before the intervention. These findings should not come as a surprise since previous research by (Juneja et al., 1998) and others has shown that the BBS correlates with FIM-measured disability in stroke patients.

According to the findings of Verheyden et al., sub-acute stroke patients saw an improvement in their TIC dynamic category after 10 h of supplementary exercise for trunk lateral flexion in addition to their regular therapy (Verheyden et al., 2006). The results of the TIS dynamic also demonstrate that there are positive outcomes

TABLE 6 Post hoc and effect size differences in control-intervention.

	Scale	Group	Mean (SD)	Power (%)	Cohen's *d*	Effect size *r*	*t*-stat	DF	Mean difference (95% CI)	*p*-value
Control versus intervention	Post TIS-S	Control	6.35 (0.71)	81.1	0.85	0.39	2.84	44	0.48 (0.13–0.82)	**0.006**
		Intervention	6.83 (0.39)							
	Post TIS-D	Control	6.87 (1.01)	100	1.64	0.63	5.40	44	1.71 (1.06–2.33)	**<0.0001**
		Intervention	8.57 (1.12)							
	Post TIS-C	Control	2.61 (0.99)	99.2	1.31	0.54	4.36	44	1.04 (0.55–1.5)	**0.0001**
		Intervention	3.65 (0.57)							
	Post TIS TOTAL	Control	15.87 (2.14)	100	1.73	0.65	5.75	44	3.17 (2.05–4.28)	**<0.0001**
		Intervention	19.04 (1.55)							
	Post_BBS	Control	39.61 (1.67)	100	4.42	0.91	14.67	44	6.65 (5.73–7.56)	**<0.0001**
		Intervention	46.26 (1.39)							
	Post_FIM	Control	82.65 (17.37)	100	1.73	0.65	5.75	44	0.48 (0.13–0.82)	**<0.0001**
		Intervention	107.09 (10.67)							

Note: Bold values indicate statistical significance.

Abbreviations: BBS, berg balance scale; FIM, functional independence measure; TIS, trunk impairment scale.

associated with the training of trunk control in conjunction with functional activities (Verheyden et al., 2006). In the current study, the pre-test and post-test scores for the TIS-static category, which was easier to administer than the TIS-dynamic and coordination categories for the participants, show a slight variation between each other, with a difference of five points out of a possible 7. However, the TIS-dynamic and coordination categories for the participants were more difficult to administer.

Clinical studies have shown that people who have had a stroke have a harder time turning their lower trunk (De Nunzio et al., 2014; Fan et al., 2020; Liang et al., 2021). Post-urography testing has shown that stroke patients don't like to move their center of pressure to the side where they have trouble moving, whether they are sitting or standing (French et al., 2016). When sitting and standing, hemiplegics shift their center of gravity to their side. Sitting exercises particularly (Kim et al., 2017). Postural deficiencies, one of the biggest risk factors for falling, may reduce a person's functional independence and impair their job performance. Postural stability affects transfer, transportation, and walking in stroke patients, predicting functional recovery. Therefore, patients in the current study were instructed to perform seven sitting exercises while in the seated position.

Another piece of recent study backs up the conclusion that we came at, which is that improving one's balance by doing hip-strategy exercises in addition to ankle-strategy exercises is effective. According to the findings of this study, the group who received training on both their ankles and hips had a shorter length of stay in the paretic side and forward area as well as a higher coefficient of performance overall movement (Park et al., 2019).

In conclusion, according to the findings of this study, patients with an early chronic stroke benefited greatly from the combination of trunk exercise and hip strategy training. Consequently, trunk muscle activation, postural control, balance, and functional independence were significantly enhanced. As a result, presenting stroke patients with this combination of trunk exercises and hip strategy training is a beneficial intervention. One of the merits of this study is that it demonstrates a relationship between a scientific instrument and a clinically useful treatment procedure.

One of our study's strengths is that we used the hip strategy to train the patient with trunk exercises. Furthermore, to the best of our knowledge, no study has coupled training in the hip strategy with trunk exercises. Our study's findings should be interpreted with care due to several limitations. A possible weakness of this research is that the majority of participants were male. Another limitation was that the strength of the lower limb muscles was not evaluated in a functioning posture; isokinetic strength testing in future studies may reveal the true benefits of hip strategy training and trunk exercises. Participants were not in the acute phase of stroke. We feel that a longer research length would further validate the motor learning benefits of hip strategy training and trunk exercises in stroke patients. In addition, we suggest that the advantages of hip strategy training and trunk exercises on postural sway and community participation be examined in future clinical studies with a larger number of participants with follow-up. A further drawback of our research was the short length of the intervention; a long-term follow-up was not conducted to see if the 4 sessions per week for 6 weeks of short-term exercise were maintained over time.

7 | IMPLICATIONS OF PHYSIOTHERAPY PRACTICE

The current study is one of the first studies that coupled training in the hip strategy with trunk exercises among stoke patients. Such combination was an effective intervention which significantly improved trunk muscle activation, postural control, balance, and functional independence. Such findings can guide national guidelines to integrate trunk exercise and hip strategy training into the management strategy of stroke patients. Future researchers must work on the mentioned exercises and strategies on a larger sample to generalize the efficiency of exercises.

AUTHOR CONTRIBUTIONS

Alanoud O. Almasoudi: Conceptualization, writing the original draft, data analysis and critically revising and approving the manuscript. **Mohamed K. Seyam:** Conceptualization, Data analysis and critically revised and approved the manuscript. **Froiland Sanchez:** Data curation, manuscript writing, and critically revised and approved the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Sultan bin Abdulaziz Humanitarian City.

PATIENT CONSENT STATEMENT

Written informed consent was obtained from each participant. Participants were informed about the nature of the study, the potential risks and benefits of their involvement, and their right to withdraw from the study at any time without any consequences. The study used anonymous clinical data for analysis.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

No applicable.

STUDY REGISTRATION

Not applicable.

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