

Association Between Motor Recovery and Balance Performance in Patients with Subacute Stroke: A Secondary Analysis of a Randomized Controlled Trial

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Abstract

Background: Motor impairment and balance dysfunction are two major contributors to disability after stroke. Motor recovery and balance performance are related and this understanding could be used to better optimize rehabilitation strategies in subacute stroke patients.

Objective: To investigate the association between motor recovery and balance performance in patients with subacute stroke.

Materials and Methods: This was a secondary analysis of 100 patients with subacute stroke (1-6 months post-stroke). The Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and Lower Extremity (FMA-LE) were used to assess motor recovery, and the Berg Balance Scale (BBS) was used to assess balance performance. The motor recovery and balance performance were analyzed using Pearson correlation.

Results: The average age of the participants was 63.97 ± 4.44 years, with 54% being male and 46% female. There were significant positive correlations between the FMA-UE and BBS scores and between FMA-LE and BBS scores. There was also a strong positive correlation between the total FMA scores and BBS scores.

Conclusions: Motor recovery is significantly correlated with balance performance in subacute stroke patients. Those who have more motor function skills have more balance skills. This study demonstrates the relationship between motor and balance recovery and suggests rehabilitation strategies that focus on both to achieve optimal functional recovery following stroke.

Keywords:

1. Stroke; 2. Motor Recovery; 3. Balance; 4. Fugl-Meyer Assessment; 5. Berg Balance Scale

1. Introduction

Stroke is one of the most important causes of adult disability globally and is associated with long-term motor, balance, mobility and activity of daily living impairments [1]. Although there have been improvements in acute stroke care, there remain a significant proportion of survivors with ongoing functional deficits which negatively impact independence, participation, and quality of life [2]. Damage to corticospinal pathways is one of the most common effects of stroke and is often characterized by weakness, abnormal muscle synergies, impaired selective movement control and decreased coordination [3].

Another important impairment after stroke is balance dysfunction, which significantly impacts mobility, falls, fear of falling and dependency in activities of daily living [4]. Balance is a key component of rehabilitation and recovery as proper balance control is essential for standing, walking, transferring, and engaging in functional activities safely [5]. Impaired balance has been shown to be a significant predictor of poor functional outcomes and delayed community reintegration following stroke in previous studies [6].

Motor recovery and Balance recovery are often considered to be intertwined processes. A successful maintenance of balance needs the coordinated activation of several muscle groups, adequate sensory integration and efficient motor control [7]. Therefore, motor dysfunction could have a negative impact on stability and motor function enhancement on stability recovery. There is evidence that recovery of motor function of the lower limb and postural control often follow similar courses during stroke rehabilitation [8, 9]. In addition, deficits in upper extremity motor function have been linked to deficits in balance performance, revealing the interactions between the motor and postural control systems [10, 11].

There are several neurophysiological mechanisms that could account for this relationship. After stroke, there is reorganization of the cortex, re-establishment of sensorimotor integration, and adaptive neuroplastic changes in motor networks. A correlation between motor recovery and cortical activation normalization has been shown by functional neuroimaging studies after stroke [12, 13]. In the same way, better balance has been associated with changes in the cortex and subcortical areas during rehabilitation [14]. The observations indicate that there are common neural substrates underlying motor recovery and balance restoration.

The Fugl-Meyer Assessment (FMA) is one of the most reliable and valid assessments of motor impairment following stroke and widely used to assess motor recovery [15]. Similarly, the Berg Balance Scale (BBS) is a validated functional balance and postural control assessment tool for stroke patients [16]. Previous studies have separately studied motor recovery and balance performance, but few studies have investigated the relationship between these outcomes in stroke patients in the subacute stage of stroke who are undergoing rehabilitation.

Thus, the aim of this secondary analysis was to examine the relationship between motor recovery and balance function in patients with subacute stroke who were enrolled in a randomized controlled trial. This

relationship may be useful for planning more effective rehabilitation strategies and predicting functional outcome after stroke.

2. Materials and Methods

Study Design:

This study was a secondary analysis of data collected from a randomized controlled trial of a structured home-based exercise program in subacute stroke patients. The present analysis was based on the correlation between motor recovery and balance performance, regardless of treatment group.

Study participants:

A total of 100 patients with subacute stroke were analysed in this study. The participants were those who fulfilled the eligibility criteria set for the parent randomized controlled trial. The inclusion criteria were: Age 51-70 years, first stroke, stroke duration 1-6 months, and the ability to follow instructions and engage in rehabilitation. Those patients with severe cognitive impairment, unstable medical conditions or other neurological disorders that impacted mobility were excluded.

Outcome measures:

1. Motor recovery:

Motor recovery was evaluated using the motor domain of the Fugl–Meyer Assessment (FMA), which is a commonly used scale to measure motor impairment after stroke. The motor domain includes the Fugl–Meyer Assessment for the Upper Extremity (FMA-UE) and the Fugl–Meyer Assessment for the Lower Extremity (FMA-LE). The FMA-UE is scored out of 66 points and the FMA-LE is scored out of 34 points, giving a total motor score of 100 points. The higher the score, the better the motor recovery and functional motor performance.

2. Berg Balance Scale:

The Berg Balance Scale (BBS) was used to assess balance, a 14 item functional balance scale ranging from 0-56. Scores higher indicate improved balance performance. The BBS has proven to be highly reliable and valid in stroke rehabilitation.

Statistical analysis:

Demographic and clinical data were analyzed using descriptive statistics. Pearson correlation coefficients were used to explore the relationships between motor recovery and balance performance. Correlations were made between: FMA-UE and BBS, FMA-LE and BBS, Total motor recovery score (FMA-UE + FMA-LE) and BBS. The data were analyzed using SPSS version 31.0.

3. Results

Participants' characteristics:

There were 100 patients with subacute stroke who participated in the analysis. The participants' mean age was 63.97 ± 4.44 years. 54% of the sample were male and 46% were female. The majority of participants

had left-sided hemiplegia (59%) and the remaining 41% had right-sided hemiplegia. The baseline demographic and clinical data are shown in Table 1.

Table 1. Demographic and Baseline Clinical Characteristics of the Study Participants (n=100)

Characteristic	Value
Age (mean ± SD)	63.97 ± 4.44
Gender [n (%)]	
Male	54 (54.0)
Female	46 (46.0)
Side of hemiplegia [n (%)]	
Left	59 (59.0)
Right	41 (41.0)
FMA-UE (mean ± SD)	40.82 ± 3.51
FMA-LE (mean ± SD)	25.47 ± 1.37
BBS (mean ± SD)	38.40 ± 3.25

FMA-UE = Fugl-Meyer Assessment–Upper Extremity; FMA-LE = Fugl-Meyer Assessment–Lower Extremity; BBS = Berg Balance Scale.

Data are presented as mean ± SD or n (%).

Correlation between motor recovery and balance performance:

There was significant positively correlation between motor recovery and balance performance (Table 2). There was a strong positive correlation between the Berg Balance Scale scores and upper extremity motor function ($r = 0.818$, $p < 0.001$). Balance performance was also significantly related to the motor function of the lower extremities ($r = 0.681$, $p < 0.001$). In addition, the overall motor recovery (combined FMA score) was highly correlated with BBS scores ($r = 0.821$, $p < 0.001$).

The results of this study suggest that patients with subacute stroke who had better motor recovery also had better balance performance.

Table 2: Correlation Between Motor Recovery and Balance Performance (n=100)

Variables	Pearson's r	p-value
FMA-UE vs BBS	0.818	<0.001
FMA-LE vs BBS	0.681	<0.001
Total FMA (UE + LE) vs BBS	0.821	<0.001

Pearson correlation coefficients (r) were used to evaluate the association between motor recovery and balance performance.

4. Discussion

The present secondary analysis examined the relationship between motor recovery and balance performance in patients with subacute stroke who were undergoing rehabilitation. Results showed strong positive correlations between upper extremity motor recovery, lower extremity motor recovery, and balance performance. Those with more motor function (Fugl-Meyer Assessment) had improved performance on the Berg Balance Scale. The results of this study suggest that motor recovery and balance restoration are closely linked aspects of post-stroke rehabilitation.

The relationship found in the present study is biologically feasible and in line with the current knowledge of post-stroke recovery. Maintenance of balance requires coordinated neuromuscular control, selective motor activation, trunk stability, sensory integration and appropriate postural responses [7]. This suggests that better motor control could lead to better postural control and stability during functional activities. Earlier studies have also shown that recovery of balance and motor impairment happen simultaneously in the early phases of stroke rehabilitation [8, 9].

Previous studies have shown a positive correlation between motor recovery and balance performance, which is consistent with the correlation found in this study. In inpatient stroke rehabilitation, Wahid et al. found a moderate positive correlation between the changes in motor function and balance performance [17]. Similarly, Schröder et al. showed that the lower-limb motor impairment was strongly related to the recovery of standing balance in the early post-stroke period [18]. The results indicate that there is a possible shared pathway and neuroplastic mechanisms for motor recovery and balance restoration rehabilitation.

The relationship between motor recovery of the upper extremity and balance was an important finding of the present study. While balance is traditionally regarded as a lower extremity function, recent research has shown that upper extremity dysfunction can have a meaningful impact on balance. Mallo-López et al. found that individuals with chronic stroke with poorer upper extremity motor function had more postural sway during standing tasks [10]. Likewise, Rafsten et al. reported that reduced motor function of the arm was an independent predictor of postural balance deficits following stroke [11]. The results agree with the hypothesis that motor recovery of the upper extremity is not only important for functional task performance but also for overall postural control.

From a clinical point of view, the observed relationship between lower extremity motor recovery and balance performance is of special interest. Weight transfer, postural adjustments, gait stability and mobility are all directly impacted by lower-limb motor impairment. De Haart et al. showed that there was a strong correlation between improvements in standing balance and functional mobility recovery in post-acute stroke patients [4]. In addition, Cinnera et al. found that the improvement of lower extremity motor function and balance had positive associations with health-related quality of life following stroke [18]. Together, these results indicate that lower-limb motor recovery is a critical factor in balance recovery and functional recovery.

There are several neurophysiological mechanisms that may account for the close relationship seen between motor recovery and balance performance. Motor recovery after stroke has been correlated with reorganization of the motor networks of the cortex and rebalancing of the hemispheric activation [12, 13]. Fujimoto et al. showed that there is also a reorganization of the sensorimotor cortex during balance recovery following stroke [14]. Based on these results, it is proposed that the recovery of motor function and balance might involve similar neural mechanisms. Furthermore, somatosensory input is also important for motor control and postural regulation. Yoon et al. showed that patients with preserved somatosensory function had greater improvement in motor recovery, balance, gait and activities of daily living during rehabilitation [19]. This evidence underpins the idea that common sensorimotor mechanisms are responsible for the improvement in both domains.

The current results are also corroborated by intervention studies showing concurrent changes in motor function and balance after rehabilitation. Motor relearning approaches, task-oriented training, exergaming interventions, and motor imagery programs have consistently shown concurrent gains in Fugl-Meyer scores and Berg Balance Scale performance among stroke survivors [20-23]. Systematic reviews of the literature have also recently found that rehabilitation interventions focusing on motor function often result in clinically relevant improvements in balance, mobility, and gait [24, 25]. The observations in this study confirm the correlation between motor recovery and balance restoration, as noted above.

These findings have implications for clinical practice. The strong relationship between motor recovery and balance indicates that a combined motor and balance rehabilitation programme would be beneficial to improve functional outcomes. Motor impairment and balance assessment can also be used to help the clinician determine patients who are at risk for poor recovery and to plan individualized rehabilitation.

This study has certain limitations. It was a secondary analysis of data from a randomized controlled trial, and was not designed specifically to study motor–balance relationships. Furthermore, clinical outcome measures were analyzed only, and not gait, trunk control, neurophysiological or biomechanical measures. Lastly, the observed relationships are not causal. Longitudinal studies with objective neurophysiological and movement analysis should be conducted in the future to further clarify the mechanisms involved in motor recovery and balance after stroke.

5. Conclusion:

The present study showed that there were significant positive correlations between motor recovery and balance performance among patients with subacute stroke. Better motor function in the upper and lower extremities was correlated with improved balance, which suggests that the upper and lower extremity motor functions recover in a closely linked way. The results suggest that rehabilitation strategies involving combined motor function and balance training may be important in maximizing recovery after stroke.

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