



# Effects of Robot-Assisted Gait Training on Stage-Based Lower Limb Motor Recovery and Muscle Tone in Subacute Stroke : A Randomized Controlled Trial

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## INTRODUCTION

Stroke-related gait impairment involves not only muscle weakness but also impaired coordination and abnormal muscle tone. Although **robot-assisted gait training (RAGT)** improves walking ability, most studies have focused on functional outcomes rather than changes in motor recovery. Because **post-stroke motor recovery progresses from synergistic movement to selective voluntary control**, the **BRS-LE** may better capture stage-based recovery than cumulative scales such as the FMA-LE. In addition, conventional spasticity scales are limited in sensitivity, whereas **MyotonPRO** can quantify **muscle-specific mechanical properties**. Therefore, this study investigated whether **additional RAGT improves stage-based motor recovery and alters muscle-specific mechanical properties**.

## METHOD

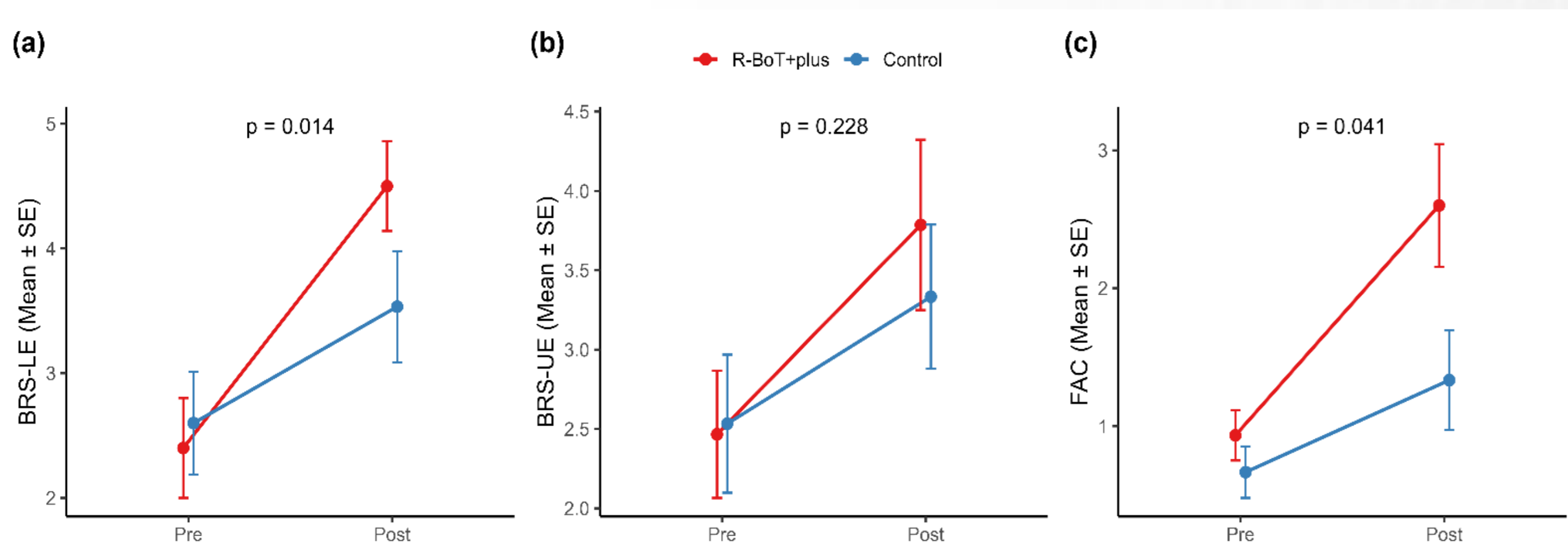
This was a prospective, single-center randomized controlled trial including 30 patients with subacute stroke. Participants were assigned to RAGT group (30 min RAGT + 30 min conventional therapy) or a control group (30 min conventional therapy), five times per week for 4 weeks. The **primary outcome was the change in BRS-LE**. Secondary outcomes included FAC, FMA-LE, MAS and MTS. In addition, **muscle mechanical properties of key gait-related muscle were quantitatively assessed using MyotonPRO**. Between-group differences were analyzed using baseline-adjusted ANCOVA, and **exploratory correlations between  $\Delta$ BRS-LE and MyotonPRO parameters** were evaluated using Spearman correlation analysis.

**Table 1. Changes in Stage-Based Motor Recovery and Functional Ambulation**

Outcome	Pre	Post	Adjusted Group Difference <sup>†</sup> (95% CI)	p-Value	Effect Size (Hedges' g) <sup>‡</sup>
BRS-LE					
R-BoT+ plus	2.43 ± 1.60	4.50 ± 1.34	1.09 (0.24, 1.94)	0.014	0.99
Control	2.60 ± 1.59	3.53 ± 1.73			
FAC					
R-BoT+ plus	0.93 ± 0.70	2.60 ± 1.72	0.81 (0.03, 1.59)	0.041	0.87
Control	0.67 ± 0.72	1.33 ± 1.40			

## Results

Both groups showed improvement over the 4-week intervention; however, the **RAGT group showed significantly greater improvement in BRS-LE (adjusted difference 1.09, p = 0.014)**, indicating enhanced stage-based motor recovery. **FAC also improved significantly in the RAGT group**.

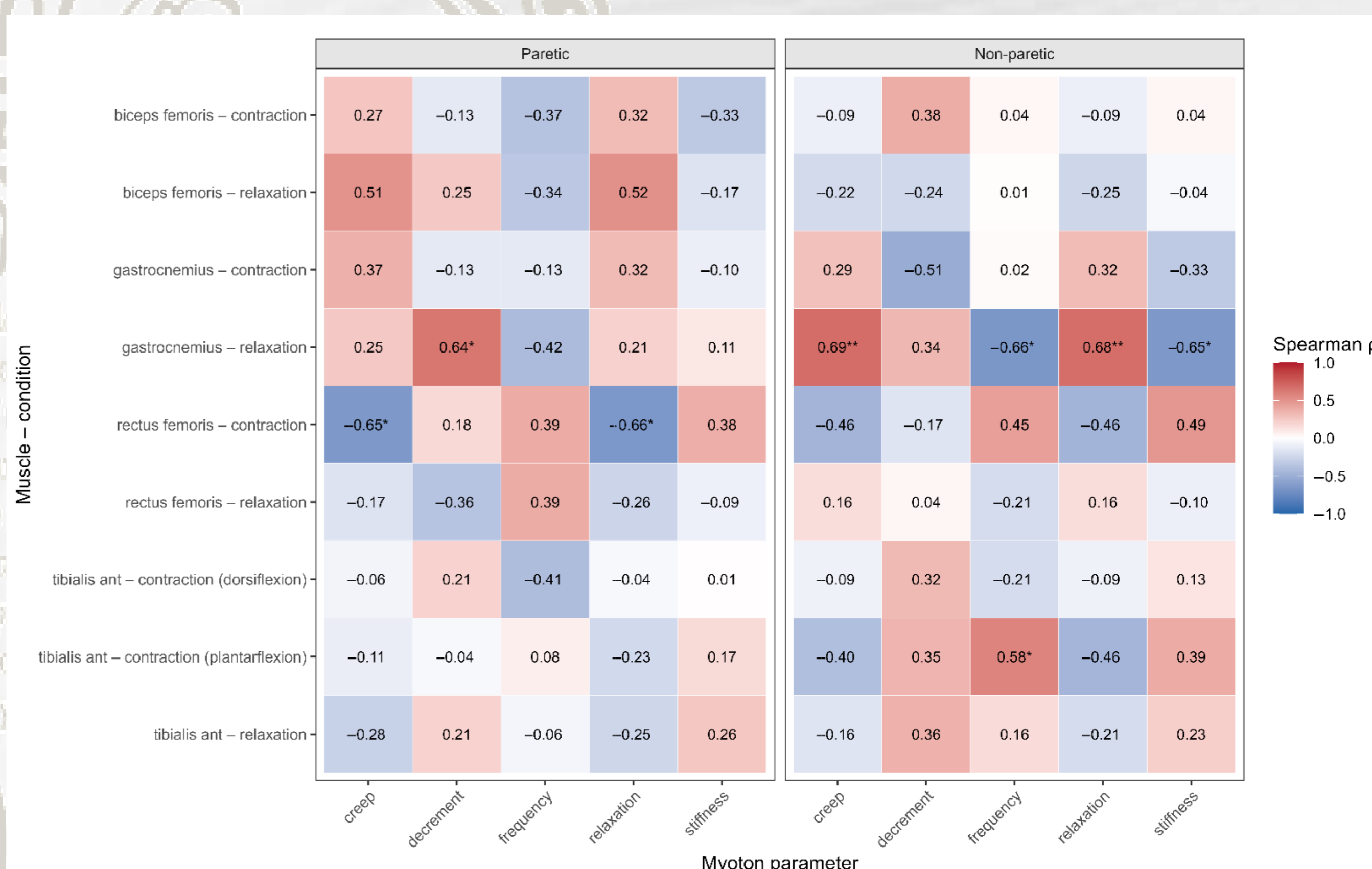


**Figure 1. Changes in stage-based motor recovery and functional ambulation.**

**Table 2. Muscle-Specific Mechanical Changes in the Paretic Biceps Femoris**

Outcome	Paretic biceps femoris	
	R-BoT Plus	Control
<b>Frequency</b>		
Mean change (SD)	1.26 ± 2.27	-0.65 ± 2.05
Group difference (95% CI)	1.91 (0.29, 3.53)	
p-value	0.020	
<b>Relaxation</b>		
Mean change (SD)	-1.55 ± 4.52	1.75 ± 4.79
Group difference (95% CI)	-3.31 (-6.79, 0.18)	
p-value	0.046	

Clinical spasticity measures, including MAS and MTS, showed small and heterogeneous changes without significant between-group differences. In contrast, **MyotonPRO revealed selective muscle-specific changes, particularly in the paretic biceps femoris (p < 0.050)**, indicating **localized neuromechanical adaptation rather than global tone reduction**.



**Figure 2. Heatmap of exploratory correlations between  $\Delta$ BRS-LE and MyotonPRO parameters.**

**No robust association** was observed between  $\Delta$ BRS-LE and MyotonPRO parameters, although **limited correlations were identified in selected muscle-parameter pairs**. This result suggests that **motor recovery and muscle mechanical changes may evolve through partially independent mechanisms during the subacute phase**.

## Conclusion

Additional RAGT resulted in greater improvement in **stage-based motor recovery** and functional ambulation. Notably, BRS-LE detected changes not captured by FMA-LE, highlighting its sensitivity in the subacute phase.

**MyotonPRO revealed muscle-specific mechanical adaptations, particularly in the paretic biceps femoris, without strong correlation to BRS-LE.**

These findings suggest that **motor recovery and muscle mechanical changes occur through partially independent mechanisms**, supporting the complementary use of BRS-LE for coordination-level recovery and MyotonPRO for mechanistic insight.

