Physiotherapy Research International

WILEY

LETTER TO THE EDITOR

Letter to the Editor: Caution Needed in Interpreting Step-to-Step Transitions in Stroke Rehabilitation

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Received: 16 June 2025 | **Revised:** 17 July 2025 | **Accepted:** 6 August 2025

Funding: The authors received no specific funding for this work.

ABSTRACT

This Letter to the Editor addresses key methodological and interpretative issues in a recent study by Covarrubias-Escudero et al. (https://doi.org/10.1002/pri.70080), which examined the effects of functional electrical stimulation (FES) on step-to-step transitions (STS) in individuals with chronic stroke. While the authors provide valuable insights into center-of-mass (CoM) mechanics during gait, we raise several concerns regarding the study's experimental design and data interpretation. First, the absence of controlled walking speed limits the ability to distinguish between genuine changes in transition strategy and speed-related adaptations, particularly since FES tends to increase gait velocity. Second, the lack of bilateral or limb-specific analysis restricts conclusions about gait asymmetry, a central feature of post-stroke locomotion. In addition, ambiguity surrounding the definition and computation of vertical velocity of the CoM ($V_{v\ CoM}$) calls into question the reliability of this outcome measure. Specifically, the methods used to estimate CoM dynamics are not fully described, which weakens confidence in the reported effects. Finally, the use of peak vertical ground reaction forces (GRF_v) may not be appropriate in pathological gait, where clear force maxima are often absent, and average-based metrics could offer more reliable alternatives. We conclude that future studies should emphasize speed standardization, bilateral analyses, and transparent methodological reporting to strengthen the clinical and scientific value of biomechanical assessments in stroke rehabilitation.

Dear Editor,

We read with interest the recent article by Covarrubias-Escudero et al. (2025) on the potential role of functional electrical stimulation (FES) in improving step-to-step transitions (STS) in individuals with chronic stroke. The authors are to be commended for revisiting a fundamental yet often criticized aspect of gait rehabilitation—the dynamics of center-of-mass (CoM) redirection during STS, a concept sometimes regarded as outdated or methodologically obsolete. Their attempt to quantify subtle biomechanical parameters is particularly welcome. Nevertheless, we would like to discuss several concerns in the hope of stimulating further refinement in the evaluation of gait transitions in pathological populations.

1 | The Influence of Walking Speed on Transition Mechanics

First, the authors analyzed gait under "comfortable walking speed" conditions, which likely varied both across and within participants (FES *vs.* No FES). However, walking speed has a profound influence on both the force and timing components of the STS. In 2019, Meurisse et al. analyzed the effect of age on the STS transition strategy. They demonstrated that in young adults, the redirection of the CoM occurred before double contact, which they termed an *active transition*, whereas in older adults, this redirection occurred after double contact, referred to as a *passive transition*. In their dataset, they also found a strong effect of speed: young adults exhibited a passive transition at slow walking speeds and an active transition at medium and high speeds.

Consequently, a comparison at uncontrolled speed, as done by Covarrubias-Escudero et al. (2025) does not allow determining whether the modification of the walking pattern arises from a reduction of speed or a genuine change in transition strategy. This is a critical point when interpreting changes in transition mode, particularly in pathological populations where walking speed is inherently variable and may itself be influenced by FES.

For this reason, protocols where speed or step-length are standardized, have been favored in recent studies assessing transition strategies (Dewolf et al. 2019, 2022; Donelan et al. 2002; Núñez-Lisboa et al. 2024; Nuñez-Lisboa et al. 2023). In the absence of controlled speed, it remains difficult to disentangle the effects of FES from simple speed-related modulations of gait dynamics. Reporting actual walking speed would thus be essential to support the interpretation of the timing shift in the occurrence of the minimal vertical velocity ($V_{v\ min}$) and the reduction in the force ratio (FR_{atio}). As FES increased speed (Aout et al. 2024; Choe et al. 2024), this alone could explain some of the observed effects, independent of any neuromuscular modulation of the push-off phase.

2 | Bilateral Analysis and Asymmetry in Stroke Gait

Second, in populations with neurological impairments such as stroke, asymmetry is a central aspect of gait dysfunction and should be explicitly addressed in analysis and interpretation. Although the authors report that FES was applied to the paretic limb, it remains unclear whether this paretic limb consistently acted as the back leg or the front leg during the analyzed STS. Without side-specific control or reporting, one cannot determine whether the reported improvements reflect increased paretic propulsion, altered compensation from the non-paretic limb, or simply leg role assignment variability. A bilateral or limb-specific analysis - considering the role and the neurological status of each limb, would greatly strengthen the conclusions.

3 | On the Definition and Application of Transition Metrics

Some terminological and methodological choices in the article merit clarification. In gait analysis, the step-to-step transition is usually defined as the part of the stride starting from the minimal vertical velocity of the CoM ($V_{v,min}$) until the maximal vertical velocity is reached (Dewolf et al. 2022; Franz and Kram 2013; Meurisse et al. 2019). In their paper, Covarrubias-Escudero et al. (2025) defined $V_{v,min}$ as "the lowest point in the vertical trajectory" of the CoM, which by definition refers to its vertical displacement. This ambiguity is further compounded by the fact that the vertical displacement is not shown in the Fig. 3 of Covarrubias-Escudero et al. (2025), even though the authors refer to it in the text. It creates confusion between displacement and velocity and may greatly impact the results (and conclusion) of the paper. Indeed, by definition, the lowest vertical position actually corresponds to the point where vertical velocity is zero (the transition from downward to upward movement), which occurs later than $V_{v,min}$.

Further, the article does not detail how the vertical velocity of the CoM was calculated. This is a critical omission, as accurate estimation of CoM motion is not trivial. Estimating CoM motion from vertical ground reaction forces (GRF_v) typically requires integrating forces over complete steps to ensure that the mean GRF_v equals body weight. Yet in the Fig. 3 of Covarrubias-Escudero et al. (2025), the GRF_v data are missing for the trailing limb during the initial and for the leading limb during final double support phases, making it unclear how vertical velocity (and/or displacement) was derived. Without an explanation of how these data gaps were addressed, the reliability of the reported $V_{v,min}$ values remains uncertain.

In addition, the reported results also raised questions about the validity of the measurements, especially since the temporal differences observed between FES and no FES [on average 0.04 ms, see Fig. 5 in Covarrubias-Escudero et al. (2025) fall within a range that could not be measured with force or kinematic signal resolution. In addition, if we assume that they made a mistake in the scale of the graph (and the data are presented in second), the authors would report a Vvmin occurring around 0.5 s. Considering the typical curves of Fig. 3 in Covarrubias-Escudero et al. (2025), in their article, 0.5 s would approximatively correspond to the lower position of the CoM. Again, it casts some doubt on whether the reported shift in $V_{v\ min}$ is reliable or clinically meaningful.

To conclude, it remains unclear whether the present study used mean values or peak values for F_{back} and F_{front} measurements. As noted in Meurisse et al. (2016), the use of peak values was explicitly avoided due to the variability and occasional absence of force maxima, which can complicate detection and reduce reliability - a common occurrence in pathological gait. Therefore, the mean vertical forces were calculated, as they were considered more representative of each leg's contribution to weight transfer. This issue is particularly relevant in the context of the current study. As illustrated in the Fig. 3 of Covarrubias-Escudero et al. (2025), the GRF_v profiles may lack well-defined peaks.

4 | Conclusion

In summary, while the study by Covarrubias-Escudero et al. (2025) provides valuable insights into the effects of FES on gait biomechanics, we believe that future research would greatly benefit from standardized speed conditions, explicit bilateral analyses, and detailed reporting of computational methods. Such methodological rigor is essential not only to accurately interpret STS, but also to demonstrate the clinical value of biomechanical approaches, which risk being dismissed as outdated or irrelevant if not grounded in robust and transparent analysis. We hope these observations will help to further strengthen future studies in this important area and to continue to advance the ongoing integration of biomechanical insights into clinical rehabilitation.

Conflicts of Interest

The authors declare no conflicts of interest.

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