Coordination of Joint Kinetics of the Front and Back Legs in the Rear-Foot-Elevated Split Squat

Ignas Palamarcukas, Phillis Soek Po Teng, Pui Wah Kong,
Physical Education and Sports Science Department,
National Institute of Education, Nanyang Technological University, Singapore
Email: NIE23.IP@e.ntu.edu.sg

Summary

The purpose of this pilot study was to investigate the coordination of joint kinetics of the front and back legs in the rear-foot-elevated split squat (RFESS). Three females and three males (30.5 ± 4.3 years, 167.3 ± 5.6 cm, 64.1 ± 5.0 kg) performed RFESS with a load of 80% of their 1-repetition maximum. The Hilbert transform method was used to compute continuous relative phase. The joint moments for of the front and back knees and hips were in-phase for the most demanding part of the repetition. However, the front knee joint moment was slightly lagging relative to the back knee at the onset and end of the RFESS. These results indicated that the joint kinetics between the front and back limbs are temporally well-coordinated.

Introduction

The rear-foot-elevated split squat (RFESS) is a frequently implemented movement in lower-body resistance training. Helme and colleagues [1] have previously reported that the rear leg contributes about 16% to the total vertical ground reaction force. However, to understand the role of the rear leg in more detail, it is necessary to examine its coordination relative to the front leg, particularly at the joint kinetics level. Therefore, this pilot study aims to investigate the continuous relative phase (CRP) between the joint moments of the front and the back legs in RFESS performed with a heavy external load.

Methods

This study included data from three females and three males (30.5 ± 4.3 years, 167.3 ± 5.6 cm, 64.1 ± 5.0 kg). All participants had at least one year of lower-body resistance training experience. The participants completed two separate familiarisation sessions, 1-repetition maximum (1-RM) testing, and a data collection session comprised of two sets of five repetitions at 80% 1-RM load with both legs taking turns as the front leg. Three minutes of rest were given between the sets.

Eight Vicon T-series cameras at 100 Hz were used for motion capture with Kistler force platforms under the front and back legs at 1000 Hz. Visual 3D was used to create a rigid body model and perform inverse dynamics analysis. The relative phase was computed using the Hilbert transform method detailed in Lamb and Stöckl [2]. CRP between the front and lack legs were compared for the hip and knee joints.

Results and Discussion

The participants achieved a 1-RM of 1.06 ± 0.21 (external load normalised by body mass). The mean CRP between the joint moments of the front and back knees as well as hips can be seen in Figure 1.

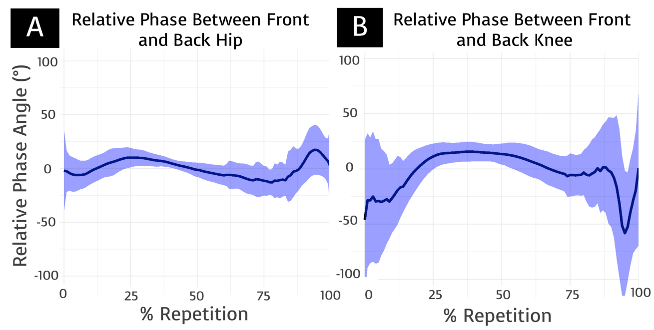

Figure 1: Mean (SD) of the continuous relative phase at 80% 1-repetition maximum in the rear-foot-elevated split squat. Negative values indicate that the front limb is lagging.

The hip joint moments are temporally synchronised, with oscillations around the relative phase angle of 0. The front and back knees are synchronised during most of the RFESS repetition, with the phase angle decreasing in the beginning and the end of the repetition. This would indicate that the front knee's joint moment leg is lagging relative to the back knee. Lastly, the increased variability in CRP at the endpoints could be due to the lower force demands of the beginning of the eccentric phase and the end of the concentric phase.

Future research should examine how CRP between the front and back legs relates to performance or balance in RFESS.

Conclusions

The joint kinetics of the front and the back limbs are relatively synchronous at a heavy load during the most demanding phase of the RFESS, with increasing variability towards the start and end of the repetition. The front knee joint moment is slightly lagging relative to the back knee at the onset and end of RFESS.

Acknowledgments

We would like to thank NTU Research Scholarship from the Nanyang Technological University, Research Support for Senior Academic Administrator (RS 2/24 KPW) from the National Institute of Education, and Student Research Grant from the International Society of Biomechanics in Sports.

References

[1] Helme M et al. (2022). *J Strength Cond Res*, **7**: 1781-1787

[2] Lamb PF and Stöckl M (2014) *Clin Biomech*; **29**: 484-493.