EFFECT OF LIMB DOMINANCE ON LOWER LIMB KINETICS, KINEMATICS AND MUSCLE SYNERGIES IN ADOLESCENT FEMALES DURING SQUATS AND DROP VERTICAL JUMPS

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Summary

This study examined the effect of limb dominance on lower limb biomechanics and muscle synergies in adolescent females performing bilateral squats and drop vertical jumps (DVJ). Twenty-six participants completed both tasks while electromyography (EMG), kinetics, and kinematics were recorded. Muscle synergies were extracted using non-negative matrix factorization and compared between dominant (DOM) and non-dominant (ND) limbs. Squat biomechanics and EMG amplitudes were consistent between limbs. DVJ hip flexion angles were higher in the ND-limb, while ankle flexion moments were higher in the DOM-limb. Semitendinosus EMG was higher in the ND-limb. These findings highlight the importance of considering limb dominance when evaluating bilateral tasks in uninjured adolescents.

Introduction

Limb dominance can influence lower limb biomechanics and neuromuscular control, impacting clinical evaluations of symmetry [1]. Adolescent females are at higher risk for ACL injuries [2], yet studies on limb dominance in this population are limited. Tasks such as squats and drop vertical jumps (DVJs) are used to assess lower limb function and symmetry [3]. This study investigates differences in joint angles, moments, muscle activations, and synergies between limbs during these tasks.

Methods

Twenty-six adolescent females (age: 13.4 ± 1.9 years) participated. EMG was collected from eight lower limb muscles. Kinetics and kinematics were recorded using a 3D motion capture system, consisting of ten infrared cameras (eight Vero and two Vantage cameras; Vicon, Nexus, UK) and force plates (FP4060-08, Bertec Corporation, Columbus, OH, USA). Muscle synergies were extracted via non-negative matrix factorization. Statistical parametric mapping (SPM) and Mann-Whitney U tests were used to assess differences between limbs and tasks.

Results and Discussion

Squat joint angles and moments were consistent between limbs. DVJ hip flexion angles were greater in the ND-limb, while ankle flexion moments were higher in the DOM-limb. Semitendinosus activation was significantly higher in the ND-limb during the DVJ. Muscle synergy analysis revealed two correlated synergy vectors in squats and three in DVJs. Scaling coefficients were higher in the DVJ, reflecting its increased load magnitude dependency. As illustrated in Figure 1, significant differences were observed in the weighting coefficients between DOM and ND limbs for synergy components C1 and C2. These findings suggest that while individual muscle activations remain similar, neuromuscular control strategies differ due to limb dominance.

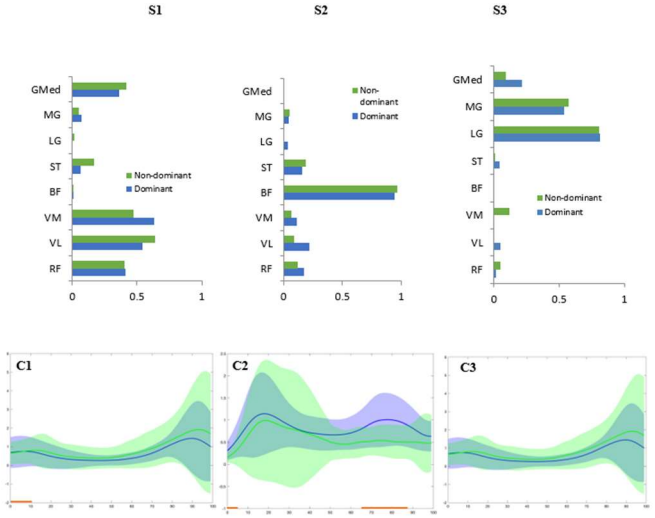

Figure 1: DVJ muscle synergies (S) and respective weighting coefficients (C) for DOM (blue) and ND (green) limbs. DVJs were normalized to 100% of time spent on force plates. Significant differences were found between the DOM and ND coefficients C1 and C2, denoted by the orange bar on the x-axis.

Conclusions

Limb dominance influences lower limb biomechanics and neuromuscular control during dynamic tasks. While synergy patterns remain consistent between limbs, activation coefficients differ, highlighting the need to consider limb dominance in injury risk assessment and rehabilitation protocols. Future research should examine these effects in injured populations.

Ackoweldgment

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References

[1] McFadden, C. et al. (2022) *Scand. J. Med. Sci. Sports*, **32**(1),106-15.
[2] Herzog, M. M., et al. (2018) *Sports Health,* **10**(6),523-31.
[3] Bizzini, M. et al. (2013) *J. Sports Sci.,* **31**(13),1-10.