Anticipatory Effects on Lower Extremity Muscle Contributions to 3D Ground Reaction Forces During Cutting

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Summary

Unanticipated cutting may increase lower extremity injury risk, partly due to altered neuromuscular control. Understanding how muscles contribute to 3D ground reaction forces (GRFs) during cutting could help provide insights into anticipatory influences on neuromuscular control. This study examined muscle contributions to 3D GRFs during anticipated and unanticipated 45° cuts in healthy females. Musculoskeletal modeling revealed the vasti and soleus contributed most to GRFs across conditions. These findings may inform neuromuscular training to reduce injury risk and enhance performance.

Introduction

Unanticipated cutting may increase lower extremity injury risk compared to anticipated cutting, partly due to differences in neuromuscular control [1]. Examining individual muscle contributions to 3D ground reaction forces (GRFs) provides insight into how muscles coordinate bodyweight support, braking, and propulsion during cutting [2]. While this has been studied in males [2], it remains unexplored in females, a group at high risk for lower extremity injuries during cutting. Therefore, this study aimed to investigate muscle contributions to 3D GRFs during unanticipated cutting in healthy females.

Methods

Ten healthy, recreationally active females (24.3±2.8 yrs, 65.1±7.5 kg; 1.68±0.05 m) performed five anticipated and five unanticipated 45° cutting trials. A 12-camera motion capture system (200Hz, Vicon) and a force platform (2000Hz, AMTI, Inc) collected marker coordinates and GRF data. Timing gates (Lafayette Instrument) were used to trigger the unanticipated stimulus and monitor entrance velocity. Scaled gait2392 musculoskeletal models [3] estimated net muscle forces using static optimization. Induced acceleration analysis [4] decomposed 3D GRFs into contributions from individual lower extremity muscles.

Results and Discussion

Qualitatively, the primary muscles contributing to 3D GRFs were consistent across anticipated and unanticipated conditions. In the AP GRF, the soleus and gastrocnemius contributed to propulsion, while the vasti group contributed to braking. For the vertical GRF, the soleus, gastrocnemius, vasti, and gluteus maximus supported bodyweight. In the medial GRF, the soleus, gastrocnemius, vasti, and gluteus medius were the main contributors, while the tibialis posterior contributed to the lateral GRF. While the functional roles of each muscle group remained unchanged between the conditions, muscle contribution magnitudes were smaller in the unanticipated condition. This is likely due to the reduced overall 3D GRF magnitudes.

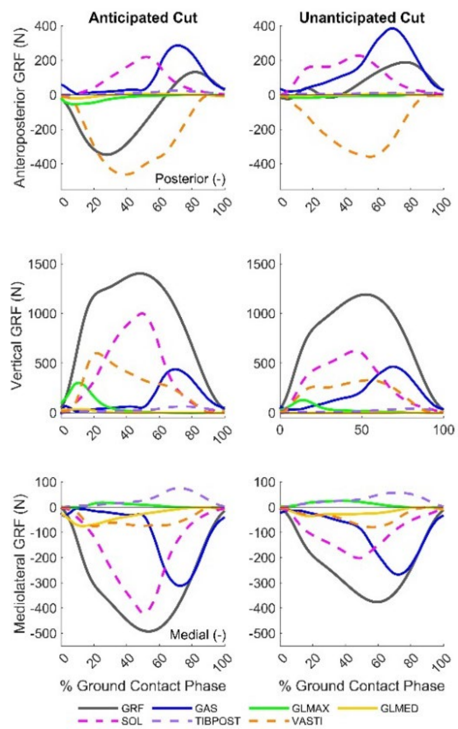

Figure 1: Ensemble averages of muscular contributions to 3D GRFs. GRF: ground reaction force; GAS: gastrocnemius; GLMAX: gluteus maximus; GLMED: gluteus medius; SOL: soleus; TIBPOST: tibialis posterior; VASTI: vasti group.

Conclusions

These findings suggest reduced muscle contributions during unanticipated cutting in females, emphasizing the need for neuromuscular training that enhances force production and coordination. Strengthening key muscles, such as the vasti and soleus, may help with injury mitigation and improve performance in dynamic sports requiring quick directional changes.

References

[1] Griffin LY et al. (2006) *Am J Sports Med.* **34**: 1512-1532.
[2] Maniar N et al. (2019) *J Biomech* **82**: 186-192.
[3] Lai AM et al. (2017) *Ann Biomed Eng.* **45**: 2762-2774.
[4] Hamner SR et al. (2010) *J Biomech.* **43**: 2709-2716.