Assessing Frontal-Plane Knee Moments and the Influence of Trunk and Foot Orientation in Lateral and Medial Side Hopping in Recreational Athletes

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Summary

Lateral and medial side hopping tasks may result in different frontal-plane knee loading patterns in healthy recreational athletes. Different external frontal-plane knee moments were observed between the hopping tasks, which could be explained by differences in lateral foot position and lateral trunk flexion. This could have implications for assessing the risk of different knee-related injuries.

Introduction

Jump-landing tasks are frequently utilised to monitor athletic performance and lower limb injury risk. Excessive external frontal-plane knee moments have been associated with knee injuries such as anterior cruciate ligament (ACL) injury [1]. These knee moments can be influenced by the trunk and foot orientation around the knee due to their effect on the external knee moment arm [2]. It is unclear if these frontal-plane knee moments differ depending on the medio-lateral direction of a single-leg side hop in a healthy, uninjured cohort. Lateral and medial side single-leg hopping tasks are valid and reliable assessments for assessing frontal-plane knee loads [3]. This study aims to (1) assess frontal-plane knee moments in the lateral and medial side hopping tasks in a healthy group of recreational athletes and (2) assess the effect of the trunk and foot orientation on these knee moments.

Methods

Sixteen (10 male, 6 female) recreational athletes (age: 23.7 ± 4.7 years, body mass: 73.7 ± 13.8 kg, height: 1.72 ± 0.09 m) were recruited for this study. Synchronised kinematic (250 Hz; 12 Vicon MX cameras) and kinetic (1000 Hz; 1 Kistler force platform, Type 9281CA) data were collected during all hopping trials. Participants were instructed to hop laterally and medially by a standardised 40 cm distance onto a force platform and rebound to their starting position. Retroreflective markers were placed on anatomical landmarks of the thorax and bilaterally on the lower limbs based on the CAST marker technique. Rigid cluster-based markers were also placed on the thighs and shanks. Visual3D (Visual3D v6 software; C-Motion, Inc., USA) was utilised to create and apply a six degrees of freedom model to the marker-based motion capture data. Kinetic and kinematic data was filtered using a 4th order low-pass Butterworth filter with a 15 Hz cut-off frequency. External frontal-plane knee moments were calculated using inverse dynamics and normalised to body mass and height. Lateral foot positions relative to the pelvis centre of mass (COM) and lateral trunk flexion angles were also calculated. A custom MATLAB (Matlab 2023b, Mathworks, USA) script extracted data from the frontal-plane variables at initial foot contact (IC) with the force platform (vertical ground reaction force > 20 N) and at peak vertical ground reaction force ($VGRF_{peak}$) during the weight acceptance phase of the side hopping. Paired t-tests with a Bonferroni correction (Matlab 2023b, Mathworks, USA) were conducted to compare the lateral and medial side hopping tasks.

Results and Discussion

At IC, frontal-plane knee moments were different between hopping tasks ($p < 0.01$) (Figure 1a), whereas no differences were observed at $VGRF_{peak}$. At IC and $VGRF_{peak}$, the lateral side hop resulted in a more laterally positioned foot relative to the pelvis COM ($p < 0.01$) (Figure 1b) and less lateral trunk flexion angle ($p < 0.01$) (Figure 1c) compared to the medial side hop. Similar differences in frontal-plane knee loading between medial and lateral side hopping tasks were observed in an ACL injured cohort [4]. These differences in frontal-plane moments at initial contact may be attributed to a more lateral foot position during the lateral side hop, which could increase the external knee moment arm resulting in an external knee abduction moment.

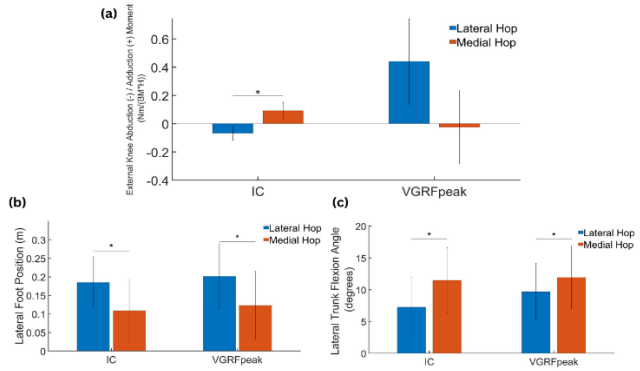

Figure 1: (a) Frontal-plane knee moments, (b) lateral foot position relative to the pelvis COM, and (c) lateral trunk flexion angles for the side hopping tasks. * Significant difference between hopping tasks ($p < 0.01$). IC, Initial Contact; $VGRF_{peak}$, Peak Vertical Ground Reaction Force; BM, Body Mass; H, Height

Conclusions

These findings suggest the lateral side hop elicits different frontal-plane knee joint loading patterns compared to the medial side hop. Differences are likely associated with the lateral foot position and lateral trunk flexion angle at IC. This could have implications for assessing the risk of different knee-related injuries.

References

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