Effect of anticipation and sex on trunk and knee biomechanics during side-step cutting: implications for noncontact ACL injury

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BACKGROUND AND AIM: Anterior cruciate ligament (ACL) sprains are among the most severe athletic knee injuries with an incidence 2-3 times higher in females than males. ACL injuries typically occur in rapidly changing, unanticipated, and noncontact athletic situations. Combined dynamic knee valgus, tibial internal rotation (IR), ipsilateral trunk tilt, and contralateral trunk rotation are considered the most common biomechanical characteristics for noncontact ACL injury, where all are exacerbated during unanticipated versus anticipated side-step cutting. We investigated the effect of anticipatory conditions and sex on these variables during side-step cutting.

METHODS: Thirty-two recreational athletes (16 males, 16 females) performed anticipated and unanticipated 45° side-step cutting tasks from a 30 cm high box using the dominant leg. In the unanticipated condition, a visual light stimulus was randomly triggered using a wireless sensor (Swift Neo wireless systems, Swift Performance, Australia) during the motion of hopping down from the box. Three-dimensional motion analysis and a force plate were used to quantify kinematics and kinetics (VICON, Oxford, England). Dependent variables included: trunk and knee biomechanics at initial contact (IC), the peak kinematic/kinetic values within 0-50% stance phase, and peak vertical ground reaction force (vGRF). We analysed variables using a two-way repeated-measures ANOVA to determine the effect of anticipation, sex, and any interactions.

RESULTS: Significant interaction effects of anticipation and sex for peak trunk rotation angle toward non-dominant leg ($F_{1,32}$=4.694, p=0.038) and peak vGRF ($F_{1,32}$=4.274, p=0.047) were evident: peak trunk rotation angle toward the non-dominant leg was significantly lower in females versus males (p=0.016) and peak vGRF significantly increased in males (p<0.001) during unanticipated cutting compared with anticipated cutting. During unanticipated cutting, significant increases in peak knee valgus angle (KVA) ($F_{1,32}$=4.543, p=0.041), peak knee IR moment ($F_{1,32}$=4.544, p=0.041), peak trunk tilt angle toward dominant leg ($F_{1,32}$=52.165, p<0.001), and peak vGRF ($F_{1,32}$=28.006, p<0.001) occurred during unanticipated versus anticipated cutting in both males and females. Females showed significantly greater IC and peak KVA (IC: $F_{1,32}$=8.846, p=0.006; peak: $F_{1,32}$=7.708, p=0.009) and lower IC and peak trunk flexion angle (IC: $F_{1,32}$=14.565, p<0.001; peak: $F_{1,32}$=23.681, p<0.001) compared with males in both cutting conditions.

CONCLUSIONS: Our findings suggest that trunk rotation in females contributes to absorbing landing impacts in unanticipated situations. In unanticipated cutting, both males and females demonstrated biomechanical features linked to increased risk for noncontact ACL injury. Furthermore, females demonstrated more trunk/knee features linked to noncontact ACL injury versus males. Improving trunk kinematics may reduce the risk of noncontact ACL injuries, especially in females.