Impact and Push-Off Force Symmetry in Dominant Versus Non-Dominant Legs During a Jump Landing/Cutting Task

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Abstract

Our goal was to examine ground reaction forces (GRF) following a series of unanticipated jump landing and cutting tasks (JLC) and the differences in these GRF's associated with leg dominance. Nine recreationally active (at least 3x/week of running, cycling, aerobics, or recreational sports participation) right leg dominant females with no history of lower extremity injuries participated in the current study. Each subject conducted a set of 12 (JLC) trails, four (JLC's) to three different directions. The subjects either performed a left cutting (LC), right cutting (RC) at 30 degrees from center or a straight ahead center cutting (CC) maneuver. Landing impact (IP) and push-off (PO) forces for both the dominant and non-dominant (IPN, IPD, PON, POD) were compared using ANOVA with repeated measures and post-hoc comparisons with t-tests. Significant differences were found between dominant and non-dominant leg IP and PO peak GRF during LC task. No significant differences were found for all other JLC tasks. These data suggest that the more extensive the change of direction opposite the dominant leg, the greater the forces acting on the dominant leg versus the forces felt during a change of direction towards the non-dominant leg of the subject. This would suggest that the amount of forces the non-dominant leg can accommodate is less than the dominant leg, which could play a role in anterior cruciate ligament injury.

Introduction

Anterior Cruciate Ligament (ACL) injuries occur at a higher rate in female athletes than in male athletes [4, 5, 7, 9, 13, 17]. On average, female athletes sustain this devastating injury 3-5 times more often than male athletes [13, 17]. There are many possible explanations for this increased injury rate in female athletes ranging from hormonal differences [1, 5, 6, 10, 12, 15] to anatomical differences [8, 16, 17]. Most commonly the ACL is injured during non-contact sporting events such as landing from rebounding in basketball to changing directions rapidly during a soccer match [2, 3, 9, 10, 11, 13, 14]. Much of the research concentrating on the non-contact mechanisms of injury (namely cutting maneuvers) have focused on sprinting then cutting [2, 3, 9, 14]. Current research also explores anticipated change of direction [2], which allows the subject time to prepare their side cutting response. In a real life sporting environment, time to respond to the changing variables rarely exists. No research of late has combined unanticipated direction changes with the JLC task or examined to what extent leg dominance has on the JLC task. It is not known whether an opposite leg push-off of or a cross over step is preferred, nor is it known if symmetry exists in landing and push-off force between dominant and non-dominant limbs when cutting to different directions.

Purpose

The purpose of this study was to assess the symmetry between dominant and non-dominant legs for the impact and push-off kinetics of an unanticipated (JLC) task. In handedness of an individual it is most often the case that the strongest hand is the dominant hand. We intend to establish any possible ramifications that leg dominance has on JLC dynamics as well as which cutting method is preferred.

Methods

Female subjects (n = 9, Age: 22.33±3.74 years., Mass: 60.23±6.89 kilograms), all right leg dominant, were required to do a two-footed landing and then cut either to the right, center, or left using their preferred cutting style. The JLC task required subjects to jump horizontally a distance of ½ of their maximal standing broad jump and reach a height vertically at the middle of the horizontal jump that was ½ of thier maximum vertical jump height. Immediately upon landing subjects sprinted at a 30 degree angle to the right (RC) or left (LC) or sprinted straight ahead (CC). Four trials to each direction were performed in a random order and the direction was identified by a light that was activated coincident with landing (Figure 1). Landings and push-offs from the JLC task were on flush mounted Kistler force plates and ground reaction forces were collected at 1250 Hz. Resultant ground reaction force peaks for impact for the dominant leg (IPD in Bodyweights, BW) and the non-dominant leg (IPN in BW) and for push-off for the dominant leg (POD, BW) and non-dominant leg (PON, BW) were calculated from three dimensional force recordings (figure 2).

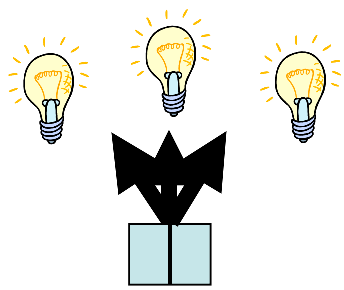
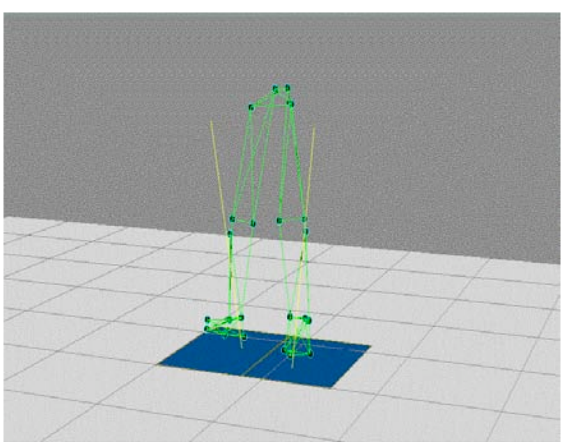
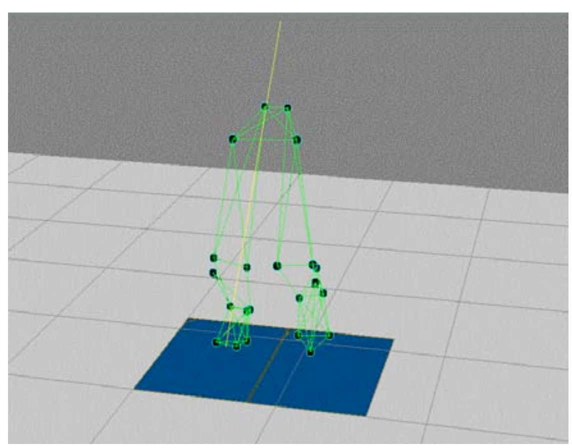


Figure 1. Unanticipated Directional lights.



A.



B.

Figure 2. A. Impact ground reaction forces B. Push-off ground reaction forces

Results

Overall the subjects employed the opposite leg push-off maneuver over the leg cross over cutting strategy. This cutting method presented the following kinetic data. For the RC and CC conditions, there were no differences between IPD and IPN (RC: 2.16±0.97 vs. 1.91±1.08; CC: 2.20±0.93 vs.1.82±0.97). When the subjects sprinted in the direction of the dominant leg or straight ahead there were no statistically significant differences on the initial landing impact forces between legs. For the LC condition, IPD was significantly greater than IPN ($p=0.005$) (2.27±1.06 vs. 1.47±0.62). The initial landing force when the subject was to sprint in the direction opposite the subject's dominant leg was greater for the dominant leg than for the non-dominant leg (Figure 3). For push-off force in the RC and CC conditions, there were no significant differences between POD and PON (RC: 1.61±0.48 vs. 2.20±0.49; CC: 2.06±0.32 vs. 1.60±0.41). The same results were found with respect to the push-off forces registered after landing. Pushing off in the direction of the dominant leg or straight ahead had no statistically significant differences between dominant or non-dominant legs. Again, when the subject pushed off to initiate the sprint in the direction opposite the dominant leg there was a statistically significant difference between the dominant leg and non-dominant leg (Figure 4). POD was significantly greater than PON for the LC condition ($p<0.001$) (2.62±0.32 vs. 1.15±0.23). The following representative line graph also shows both impact and push-off peaks as they compare to the three cutting directions (Figure 5).

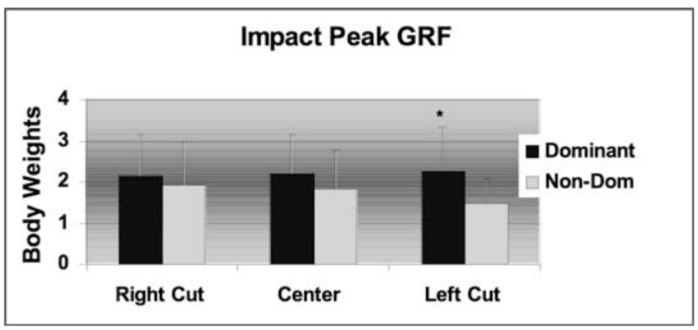


Figure 3. Impact peak ground reaction forces (GRF) for the dominant and non-dominant legs for each of the three cutting directions. Left cutting task is the direction opposite of the subject's dominant leg.

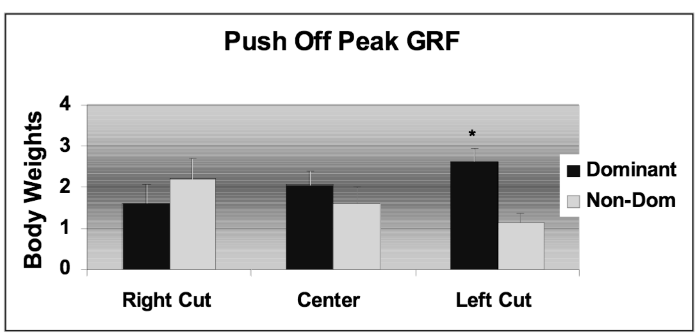


Figure 4. Push-off peak ground reaction forces (GRF) for the dominant and non-dominant legs for each of the three cutting directions. Left cutting task is the direction opposite of the subject's dominant leg.

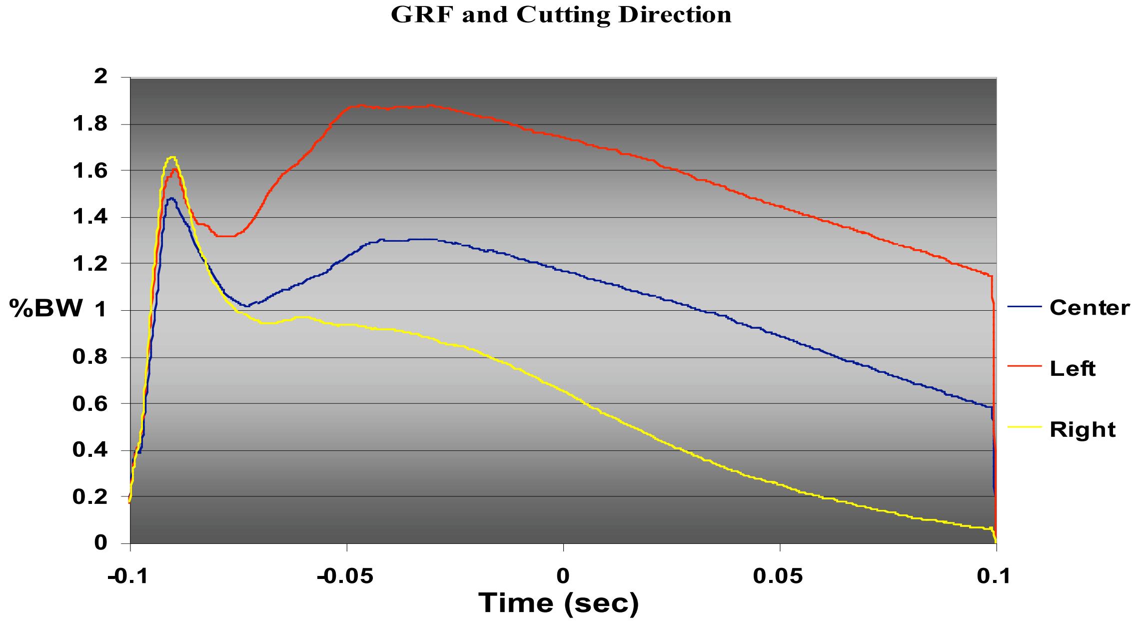


Figure 5. Representative graph of impact and push-off peaks (registered as a percent of subjects bodyweight over time in milliseconds) during a JLC tasks for the three directions.

Conclusion

Of the three conditions assessed for the JLC, the more extensive the cut to the non-dominant side, the greater the impact and push-off force on the dominant leg compared to the non-dominant leg. These data show that the dominant leg is capable of accommodating a greater impact force and a greater push-off force when cutting in the opposite direction. These data also suggest that the non-dominant leg is less capable of accommodating an unanticipated JLC task in a sporting event which may leave it more susceptible to ACL injury. An added inference that can be made from these data suggests that if the subject uses poor landing and push-off techniques during a dominant leg JLC event, there are greater ground reaction forces present to possibly injure the ACL of the athlete. Further research is needed to confirm if in fact the non-dominant leg is more susceptible to ACL injury. Our research lacks kinematics data to support our kinetic findings. Future research should focus on such data as well as a contrasting study with all subjects having left leg dominance. Our data lacks this element of comparison which is necessary in order to have an even greater understanding of ACL injury rates in female athletes.

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