BIOMECHANICAL ASSESSMENT OF CHANGE OF DIRECTION PERFORMANCE IN MALE UNIVERSITY SOCCER PLAYERS

Ken Morrison, Wayne J. Albert, and Usha Kuruganti

Kinesiology, University of New Brunswick, Fredericton, Canada

The purpose of this study was to identify biomechanical variables that distinguish change of direction performance in an athletic population. Twenty varsity men's soccer athletes were recruited. Motion capture and force plate data were collected simultaneously during the plant phase of a 505 agility test. The median time to complete the agility task was used to distinguish a "fast" group (n=10) and a "slow" group (n=10). An ANOVA (0.05 alpha level = was used to compare groups' kinematic and kinetic variables. Several differences were found between groups including: contact time, transition, relative horizontal to vertical ground reaction force, center of mass height, torso lean, pelvis rotation, spine rotation, hip adduction/abduction. The findings suggest that fast and slow change of direction performance adopt different technical strategies.

KEY WORDS: change of direction, agility, biomechanics.

INTRODUCTION: Agility plays a crucial role in sport and is often involved in pivotal moments of a competition where an athlete must avoid or track a competitor, or change direction to be first to a ball or gain position. These moments often result in the scoring or conceding of a goal or point which ultimately determines the outcome of the competition (Kaplan, Erkmen, & Taskin, 2009). Therefore, establishing a foundation of scientific research that explains the relationship between biomechanics and change of direction (COD) performance can help athletes maximize their athletic potential by improving quality of movement and force application.
The purpose of this study was to determine if athletes who change direction faster adopt different biomechanical strategies than athletes with slower COD. Changing direction is a complex task that requires coordination of multiple joint segments to decelerate movement in one direction and accelerate in a new direction. Because of the complexity of movement coordination and force application required for effective change of direction, it was hypothesized that athletes who demonstrate quicker COD would apply different biomechanical strategies than athletes who exhibit slower COD.

METHODS: Twenty athletes from the University of New Brunswick's varsity men's soccer team were recruited for the study. Each athlete performed 4 trials of the 505 agility test (Draper et al., 1985), on their dominant side to assess COD performance. Athletes fastest trials were used for analysis. Thirty-nine retro-reflective markers were used to identify the athlete and develop a 3D biomechanical model using 12 VICON T160 cameras and Plug in Gait (Vicon, Oxford UK, www.vicon.com). The COD was performed so that the athletes dominant leg contacted a Kistler force plate during the plant phase of the COD (Kistler Instruments, inc., Amherst, NY). The median time to complete the COD task was used to divide the athletes into a "fast" group (n=10) and a "slow" group (n=10). Groups joint kinematics, center of mass position and kinetics were compared between three sub-phases during foot contact: weight acceptance, transition, and push off. An Analysis of Variance was performed to determine differences between groups biomechanical variables. To ensure that groups were homogenious and parametric statiscal analysis was appropriate a Levene's test of homogeneity was performed.

RESULTS: Athletes in the fast group were found to have shorter overall contact time (p=0.011) and relative time spent in transition (p=0.001) when compared to the slow group.

The fast group also produced more relative horizontal to vertical ground reaction force during weight acceptance (p=0.03) and push off (p=0.002). Kinematic analysis revealed that during weight acceptance faster athletes displayed a lower centre of mass (p=0.003), greater torso lateral lean (p=0.018), and greater pelvis rotation (p=0.004) than slower athletes. During transition the fast group had greater torso lateral lean (p=0.004), less spine rotation range of motion (p=0.035), and less hip adduction/abduction range of motion (p=0.02). Finally, the fast group was found to maintain greater torso lateral lean (p=0.015) throughout push off and a lower centre of mass at toe off (p=0.015).

DISCUSSION: This study was exploratory in nature and intended to identify biomechanical variables that distinguish COD performance between male collegiate soccer players. It is important to note that COD has several distinct phases that contribute to overall task performance including: decceleration, transition (plant phase), and acceleration. The present study focused on the transition phase of the COD, which was broken into three sub-phases for analysis: weight acceptance (eccentric), transition (amortization), and push off (concentric). Future research will be required to analyze different decceleration and acceleration strategies during COD.

Several kinetic and kinematic differences were identified between groups which could potentially influence performance. When analysing kinetics it appears that contact time and direction of force application differentiate the fast and slow COD groups. Previous research has suggested that contact time may have implications on performance of various athletic tasks (Murphy Lockie, & Coutts, 2003). When considering change of direction performance, it is logical to think that if an athlete is able to transition from the plant phase to the acceleration phase in less time with equal efficiency then they will decrease their overall COD time. Faster athletes in this study were found to have shorter overall contact time than slower athletes, which supports this explanation and previous research (Murphy, Lockie, & Coutts, 2003; Flanagan & Comyns, 2008). While understanding overall contact time and its role in change of direction performance is important, it is also important to consider how athletes with more effective COD are able to decrease their contact time. when considering each athlete’s relative time spent in each phase during contact, it was found that fast athletes spent less relative time in the transition phase of the change of direction. This finding suggests that more effective athletes were able to shift from eccentric to concentric muscle action faster than less effective athletes.

It also appears that the direction of force applied to the ground by athletes plays a major role in performance. Results from this study suggest that the ratio of horizontal to vertical GRF during the acceptance and push off phases of the COD may play a critical role in performance. Many of the kinematic differences between groups in the present study also appear to promote the ability to produce horizontal force while changing direction. The purpose of the acceptance phase is to decelerate momentum from the current direction of travel, while the goal of the push off phase is to accelerate and increase momentum in a new direction. Both of these tasks require a large amount of horizontal force with the primary plane of movement being in the horizontal direction. It seems logical that if an athlete is able to produce more force horizontally while maintaining enough vertical force to maintain friction with the ground they will improve their ability to decelerate and accelerate during change of direction. Overall magnitude of ground reaction force in any direction did not differ between groups during any of the change of direction phases. This suggests that direction and timing of force production plays a more critical role in COD performance than overall magnitude.

Many of the kinematic findings suggest that postural positioning has a substantial impact on COD performance. During weight acceptance faster athletes were found to have a lower centre of mass which helps increase stability and create a more horizontal impulse to assist in deceleration. Faster athletes also demonstrate more forward and lateral lean of their thorax, which may assist athletes in lowering centre of mass during weight acceptance. The lateral lean of the thorax is also a postural adjustment that promotes the athlete’s ability to apply horizontal force to the ground that was discussed earlier as potentially beneficial to COD performance. Faster athletes may increase the lateral lean of their thorax to keep their centre of mass further in their intended movement direction, while allowing their legs to drive their centre of mass from behind, much like a sprint start and the power line. It is important to note that faster athletes lowered their centre of mass and leaned further in their intended movement direction without bending or flexing their spine more than the slower athletes. This suggests that fast athletes accomplish these postures by positioning their whole body to achieve their low/leaned posture, not just their trunk and spine.

Faster athletes were also found to tilt their pelvis further toward their lead plant leg and rotate their pelvis further toward their intended change of direction at foot contact. The increased lateral tilt of the pelvis could potentially allow the fast athletes to push their base of support further from their centre of mass to increase horizontal force and power line angle, while the increased rotation of their pelvis would decrease the amount of rotational friction and torque placed on the ground and lower extremity joints which would increase efficiency while decreasing joint damage and injury risk.

The transition phase of the COD requires athletes to change from eccentric to concentric muscle action as fast as possible which requires a great deal of strength and stability. In the current study, faster athletes were found to have less range of motion, or what could be thought of as more stability, during the transition phase for spine rotation and hip abduction/adduction. Hip stability during COD has previously received some research attention, mostly to identify injury mechanisms during COD, in particular ACL injuries in females. Previous research suggests that ACL injuries are most likely to occur near foot contact with the leg in a more extended position (Besier et al. 2000; Landry et al. 2007). Given that the slow group displayed greater hip abduction/adduction range of motion in the transition phase when the leg is in a more flexed position and has already undergone weight acceptance it is thought that the difference in hip range of motion observed in this study is more likely to impact performance than predispose athletes to injury. It is possible that if the fast group is able to maintain a more stable hip position during the transition phase then they will be able to transition from eccentric to concentric muscle action quicker. This could also partially explain why the fast group spends less relative time in transition compared to the slow group that ultimately decreases contact time and improves efficiency.

Less research has analyzed spine angles during COD so it is difficult to compare and interpret the greater spine rotation demonstrated by the slow group in the transition phase. Previous research has suggested torso lean or rotation impacts lower bodt kinematics (Dempsey, Lloyd, Elliott, Steele, Munro, & Russo, 2007). In the current study maintaining a more stable spine may help the fast group preserve lower body stability and sustain their leaned posture throughout transition. This hypothesis is supported by the fact that much like the acceptance phase, the fast group displayed more lateral lean at the thorax and pelvis, suggesting that the fast group maintains a consistent and stable leaned posture during COD.

At push off the faster athletes already had their centre of mass further in their intended direction of acceleration as a result of the postural positions they adopted during weight acceptance and transition. Effectively, the fast group's postural decisions during weight acceptance and transition allowed them to establish a power line to accelerate from during push off. This is again supported by the fact that the fast group demonstrated a more lateral leaned posture at the thorax and pelvis with their centre of mass further in the direction of their intended movement during push off.

CONCLUSION: Very few research studies have analyzed change of direction performance from a technical perspective. The present study is one of the first studies to investigate change of direction performance while analyzing kinematics and kinetics simultaneously. This study has identified a number of variables that distinguish COD performance in an athletic population which provides future researchers with pertinent information about what technical factors potentially differentiate performace. Coaches and athletes may also apply this information in training to enhance COD performance.

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