DIFFERENT MOVEMENT TASK STRATEGIES DURING UNANTICIPATED CUTTING MANOEUVRES – PILOT STUDY

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The aim of this study was to describe different movement task strategies during unanticipated cutting manoeuvres based on initial foot contact and angle in the frontal plane at the instant of first contact with the ground. Four female athletes participated in this study. Nine infrared cameras and force platform were employed to collect the kinematic and kinetic data. Athletes used four different movement task strategies during unanticipated cutting manoeuvres (45°) in initial contact with the ground. The results of this pilot study showed that combination of rearfoot strike and knee valgus angle position at the initial contact may increase the risk of an ACL injury.

KEY WORDS: biomechanics, ACL injury, prevention

INTRODUCTION: Women have a higher risk of knee joint injuries in 9 out of 12 sports, including soccer, downhill skiing, hockey, handball, alpine skiing and basketball (De Loës, et al, 2000). Female adolescents who participate in jumping, cutting and pivoting sports suffer ACL injuries at a four to six-fold greater rate than males participating in the same sports (Hewett et al., 1999). 70% of ACL injuries are non-contact injuries (Myklebus et al., 1997; Boden et al., 2000). ACL rupture occurs in 2/3 of cases during non-contact situations involving cutting manoeuvres or landing (Ford et al., 2003). The literature is inconsistent from the point of view of ACL injury. A number of authors suggest that ACL injury occurs between 17 - 50 ms after initial contact (Krosshaug et al., 2007; Shin et al., 2007). The knee joint is in the low flexion range (0° - 30°) during injury (Beynnon et al., 1995; Ford et al., 2003). Players can solve the same motor task (landing) by different ways in the risk interval shortly after initial contact (Zahradník et al., 2015). David et al. (2017) related injury risk to footfall patterns but not knee valgus or varus position. Therefore, there is an assumption, that players may have a different risk probability of ACL injury depending on the ways of solving the movement task. Currently it is unknown, that the way of solving of cutting manoeuvres relates to incidence of ACL injury. The aim of this study was to describe different movement task strategies during unanticipated cutting manoeuvres (45°) based on initial foot contact and knee angle in the frontal plane at the instant of first contact with ground. We hypothesised that different movement task strategies will be associated with individual participants.

METHODS: Four female athletes (age 17,5 ± 3,8 years; height 165,5 ± 5,9 cm, weight 58.3 ± 4,8 kg) from sports with a high incidence of ACL injury: volleyball (n=2), handball (n=1), floorball (n=1) were recruited for this study. The participants had no musculoskeletal injuries, no history of surgery for traumatic injury of lower extremities, and were not taking hormonal contraceptives. Participants were right leg dominance. The experimental setting was based on a real game situation. The task was an unanticipated cutting manoeuvre. The change of direction was set at 45° during self-preferred approach speed (4,79 ± 0,23 m/s). A self-selected speed was chosen because the athletes performed in different sports. The approach speed was measured using a time-measuring device (P-2RB / 1, EGMedical, Ltd., Czech Republic) and two photocells (OPZZ, EGMedical, Ltd., Czech Republic). The first photocell was placed at the 90 % area stride distance from the center of the force plate and the second 2 m from the first photo cell (Kim et al., 2016). The position of the first photocell was based on the length of the participant´s stride during running and triggered a signal for change of direction by arrow to the left. An arrow pointing up indicated run straight ahead. Each player performed 5 successful trials of unanticipated cutting manoeuvre. Force platform (Kistler, 9286 AA,

Switzerland) sampling at 1200 Hz was used to determine ground reaction force. A motion-capture system (Qualisys Oqus, Sweden) consisting of nine infrared cameras was employed to collect the kinematic data at a sampling rate of 250 Hz. Retro-reflective markers were attached to the athletes' lower limbs according to a recommendation of the C-motion Company (C-motion, Rockville, MD, USA).
Raw data were processed using Visual3D software (C-motion, Rockville, MD, USA). The range of the analysed motion started with the first contact with the ground reaction force (GRF) and finished with first maximum ground reaction force. Force platform data were filtered using a fourth-order low-pass Butterworth filter. The motion capture coordinate data were low-pass filtered using the fourth-order Butterworth filter with a 12 Hz cut-off frequency. In order to determine the local coordinate system of the segment, all segments were modelled as frusta of right circular cones, while the pelvises were modelled as cylinders (C-motion, Rockville, MD, USA). The local coordinate systems were defined using the standing calibration trial for each participant (C-motion, Rockville, MD, USA). The analysis in this study includes data related to the right lower limb only. The internal varus-valgus moment on the right knee was calculated using a Newton-Euler inverse dynamics technique (Hamill & Selbie, 2004). The types of solution movement task were classified based on initial foot contact (fore-rear foot contact) and the knee angle in the frontal plane (varus-valgus) at the instant of first contact with the ground.

RESULTS: The results show four types of different movement task strategies (Figure 1). Mean, standard deviation for all dependent measures are shown in Table 1.

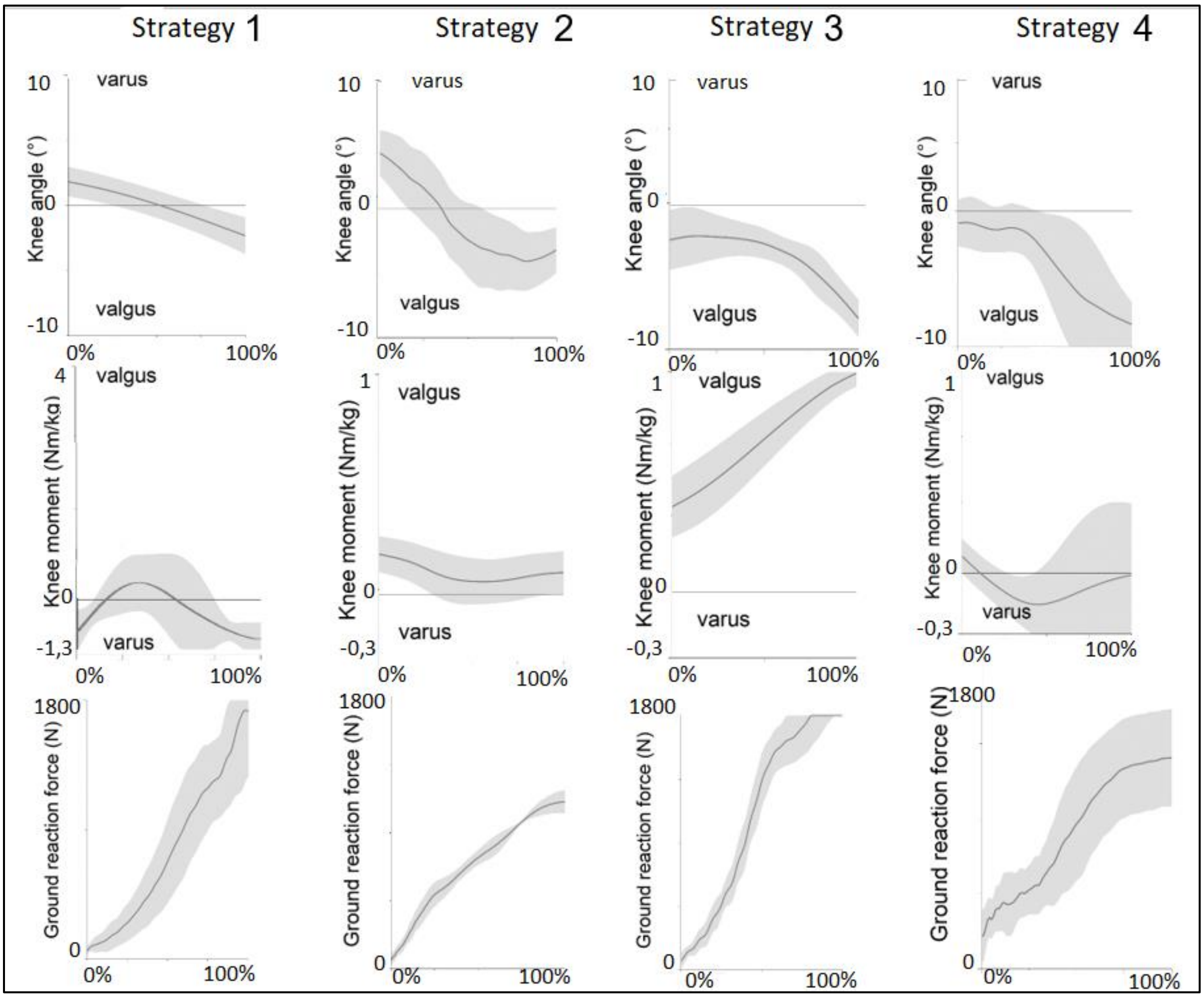

Figure 1: Frontal knee angle, moment and vertical ground reaction force of different types of movement strategies during unanticipated cutting manoeuvres (from initial contact to first peak of vertical ground reaction force).

Table 1: Summary of first peak of maximum reaction force of the frontal knee angle, internal moment and vertical ground reaction force of different movement task strategies (M ± SD) on the right lower limb at the instant of first peak of GRF in four types of solution movement tasks (n=4).

Type of solution	Strategy 1	Strategy 2	Stretegy 3	Stretegy 4
Angle (varus/valgus) (°)	1.97 ± 0,76	3.20 ± 1,78	-7.79 ± 1,17	-8.39 ± 1,67
Moment (valgus/varus) (Nm.kg-1)	-1.45 ± 0,75	0.09 ± 0,13	1.24 ± 0,15	-0.06 ± 0,62
Vertical GRF (N)	1739.91 ± 451,11	1103.03 ± 77,9	2082.34 ± 205,21	1266.65 ± 292,21
First contact	Rearfoot	Forefoot	Rearfoot	Forefoot

Note: (+) Varus angle, valgus moment; (-) valgus angle, varus moment

DISCUSSION: The aim of this study was to describe different movement task strategies during unanticipated cutting manoeuvres (45°) based on initial foot contact and knee angle in the frontal plane at the instant of first contact with the ground. Zahradnik et al. 2015 assessed a potential injury risk of different movement task strategies at the instant of the first peak of ground reaction force. These researchers identified four types of different moving task strategies during landing movements. Other studies also presented movement patterns based on rearfoot and forefoot strikes (David et al., 2017; Donelly et al., 2017). The types of different movement task strategies were evaluated based on initial foot contact and knee angle in frontal plane at the instant of first contact with the ground for the four participants in this study. We found that to solve this movement task, athletes preferred the following: either a knee valgus or varus angle and either a forefoot or rearfoot position of the foot at the instant of first contact with ground. Participant 1 preferred the rearfoot and knee varus position strategy versus participant 2 who preferred a knee varus angle position with forefoot strategy. Participants 3 and 4 solved the movement task in the knee valgus position but participant 3 with the rearfoot position and participant 4 with the forefoot position. We found that participant 2 showed a higher knee varus angle than participant 1 at initial contact. Both participant 1 and 2 showed a general tendency to decrease the knee varus angle and subsequently increase the knee valgus angle from initial contact to first peak of vertical GRF. Participant 1 showed a knee varus moment versus participant 2 who showed a knee valgus moment. Vertical GRF was higher in participant 1 versus participant 2 in interval from initial contact to first peak of vertical GRF. However, both participants 3 and 4 showed a knee valgus angle at initial contact with an increasing tendency to be closer to the first peak of vertical GRF, but their knee moment was different. Participant 4 had a mostly knee varus moment during interval from initial contact to first peak of vertical GRF. The knee valgus moment of participant 3 was the highest of all participants in this study and has an increasing tendency from initial contact to first peak of vertical GRF. This knee valgus moment indicates predictive risk factor of ACL injury (Hewett et al., 2005). Participant 3 had the highest knee valgus moment and vertical GRF of all participants who solved the movement task by knee valgus moment and rearfoot strike. Participant 2 exhibited the lowest vertical GRF with knee varus angle and forefoot strike in initial contact.

CONCLUSION: In this pilot study, we showed that each athlete performed the unanticipated cutting manoeuvres differently. According to Zahradnik et al. (2015), the most risky behaviour was a knee valgus angle and a rearfoot position. This corresponded also with Donelly et al. (2017). This strategy was only adopted by participant 3 who had the highest knee valgus angle of the others in this study. Other strategies performed by the remaining participants were considered less risky. We concluded that there are strategies that can solve the movement task and that some athletes, possibly due to other factors, are predisposed to select a strategy with less risk for injury.

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