THE EFFECT OF RESTRICTING THE VISUAL SENSE ON THE KINEMATICS AND KINETICS OF A CUTTING MANOEUVRE

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The purpose of this study is to investigate the kinematic and kinetic parameters when performing a cutting manoeuvre blindfolded. Male rugby and football players (n=7) performed a 60 degree cutting manoeuvre blindfolded and without restriction while recording kinetic and kinematic data. Restricting the vision led to a significant decrease of knee and hip flexion angle, a decreased inversion in the ankle and a tendency for higher knee-stiffness in the sagittal plane. The hip joint moment was significantly reduced while the knee joint moment was significantly increased. Considerable effects occurred in the kinematic and kinetic parameters, while the approach velocity and contact time showed trivial effects.

Key WORDS: cutting manoeuvre, blindfolded, kinematic and kinetic

INTRODUCTION: The cutting manoeuvre is a key component in team sports such as football or rugby to evade the opponent player (McLean, Lipfert, & van den Bogert, 2004). This movement is often used to analyse biomechanical factors linked to performance and injuries in the lower limb joints (Benjaminse, Gokeler, Fleisig, Sell, & Otten, 2011). In a future study the cutting manoeuvre should be used to investigate the effect of different surfaces on the movement. The mentioned study will deal with participants who should remain unaware on which surface they perform this task. Restricting the visual sense is a possibility to keep the participants unaware, but it might change the movement pattern. There is limited research knowledge on the actual changing in movement when performing with restricted senses. Demura and Demura (2011) measured a decreased walking speed under restriction of visual input which contradicts the results from Philbeck, Woods, Arthur, and Todd (2008), who found faster walking speeds when walking blindfolded. In landing tasks larger peak ground reaction forces and smaller knee joint rotations are found when restrict the visual sense (Santello, McDonagh, & Challis, 2001). It is suggested that participants undergo a learning effect and gain confidence while being blindfolded, which leads to adaptations towards the original movement (Philbeck et al., 2008) . Therefore the aim of this study was to investigate the effect of visual restriction on the lower limb joints kinematics and kinetics in a cutting manoeuvre.

METHODS: 7 male university level soccer and rugby players (176.6 ±4.4 cm, 75.1 ±9.7 kg, 20.8 ±3.9 years) participated in this study. The participants wore their own shoes while they performed a cutting manoeuvre on a Mondo surface in a laboratory setting. This movement was performed in the condition no restriction (NR) and visual restriction (VR) by wearing blindfolds. The cut was performed with the right leg after a 5 m acceleration phase, with an angle of 60 degree to the left side. After the cut-step the participants were requested to accelerate for another 3 strides. Prior to data collections each participant underwent a 10 minute warm-up, which also was used to familiarise the participants to the visual restriction. Three-dimensional (3D) kinematic data was collected via a 13 infrared-cameras system (Vicon Nexus, Los Angeles, USA) while kinetic data was simultaneously collected using a force plate (Kistler Instrumente AG, CH) implemented in the floor. Sample frequency for kinematic data was 250 Hz and for kinetic data 1000 Hz. To calculate 3D kinematics of the right lower limb joints reflective markers were placed on the skin according to the Cleveland Clinical marker set. The order of the conditions (NR, VR) was randomised and each condition contained 3 valid trails. A trail was considered valid when the participants hit the force plate with the entire right foot and changed the running direction to 60 degree. Subsequent to data labelling in Vicon Nexus, data was processed using Visual 3D (C-Motion Inc., USA). For data filtering a low pass Butterworth-filter with a cut off frequency of 25 Hz for kinematic data and a cut off frequency of 40 Hz for kinetic data was used. Data was processed and time normalised to 100% for the ground contact phase of the cutting manoeuvre. The ground contact phase was defined by the vertical ground reaction force (F_Z) exceeding the threshold of 25 N. Kinetic data was further normalised to subject mass. For each parameter the mean of the 3 trials was calculated for each condition. Vertical ground reaction force was split into 3 phases (Figure 1): Weight acceptance (WA)—from touchdown to the first trough, peak push off (PPO)—10% either side of the second peak and final push off (FPO) as the last 15% of stance phase (Besier, Lloyd, Cochrane, & Ackland, 2001; Kaila, 2007). In these phases the mean was calculated for the 3D ankle, knee and hip joint angles, internal joint moments and sagittal joint powers. Further processed parameters were the range of motion (ROM) and the peaks of ankle, hip and knee joint angles, internal joint moments and joint powers for each dimension. Additionally the approach velocity before the cut ($v_{(i)}$) was computed by mean velocity of the hip centre of mass 25 frames before touchdown. The sagittal ankle, knee and hip joint-stiffness according to the equation from Kuitunen, Komi, and Kyrolainen (2002) were calculated. Due to the small sample size a Wilcoxon-test was implemented to determine differences between the two conditions VR and NR with and alpha level set to 0.05. Furthermore Cohen's d effect size was calculated.

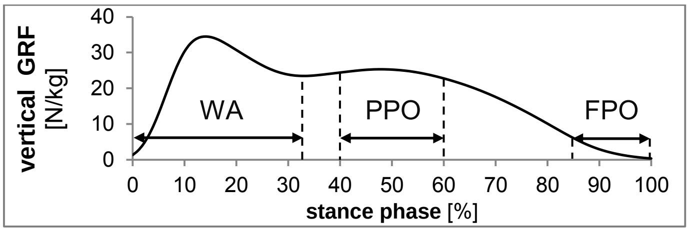
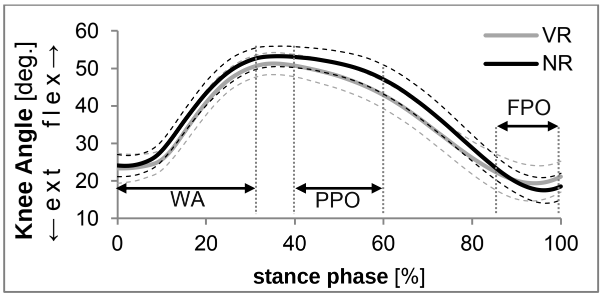


Figure 1: Schematic of stance phase, split by using vertical ground reaction force (GRF). WA: weight acceptance; PPO, peak push off, FPO, final push off (Besier et al.,2001, Kaila, 2007).

RESULTS: There was no difference in approach velocity $v_{(i)}$ between the conditions (NR: 4.77 ±0.79 m/s; VR: 4.70 ±0.64 m/s). The contact time was significantly shorter when participants were blindfolded, but the effect is trivial with a change of 2.4 % (NR: 207.24 ±30.44 ms; VR: 202.29 ±30.77 ms). No differences occurred in the FPO phase; therefore the results are only presented for the phases WA and PPO. For the ankle joint the only significant value was identified by a decreased inversion during WA when blindfolded (NR: 18.7 ±5.7 deg.; VR: 17.4 .±5.4 deg., *d*=small). All other parameters calculated indicate that restricting the vision led to significant changes in the knee and hip joint in the sagittal plane. The kinematic effects of blindfolding were found to be similar for both the knee and the hip joint, in significantly decreasing the joint flexion angle in the PPO (knee: 3.0 ±1.4 deg.; hip: 8.6 ±0.5 deg.) (Figure 2). The reduction of ROM by 4.4 ±3.1 deg. (knee) and 2.9 ±0.4 deg. (hip) respectively underpins the reduced knee and hip flexion (Table 1 and 2).



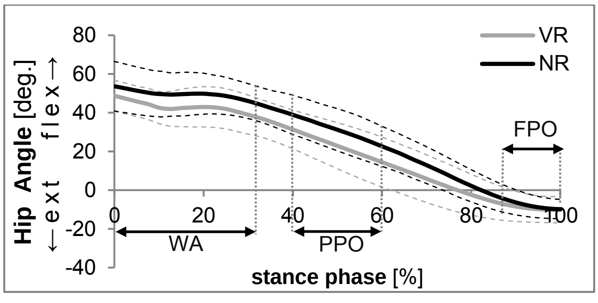


Figure 2: Mean ±SD flexion\extension angle in the conditions: visual restriction (VR) and no restriction (NR) in the knee joint (left) and hip joint (right) during stance phase with to the phases weight acceptance (WA), peak push off (PPO) and final push off (FPO) indicated.

Table 1: Knee: Means (±SD) of peak and range of motion (ROM) and mean phase parameters (weight acceptance phase (WA) and peak push off (PPO)) for sagittal plane kinematic and kinetic variables for no restriction (NR) and visual restriction (VR)

Sagittal Plane Knee Variables	NR Mean ± SD	VR Mean ±SD	Cohen's d	Sign.
Kinematic [deg.]				
Peak knee flexion	53.5 ±5.9	51.6 ±6.5	0.3	*
WA: mean knee flexion	35.8 ±4.4	34.4 ±4.5	0.3	n.s.
PPO: mean knee flexion	52.2 ±5.7	49.2 ±7.1	0.5	*
ROM	38.3 ±4.4	35.4 ±4.0	0.7	n.s.
Moment [Nm/kg]				
Peak knee extension	-3.67 ±0.40	-3.96 ±0.53	0.6	*
WA: mean knee extension	-0.76 ±1.37	-1.62 ±0.57	0.8	n.s.
PPO: mean knee extension	-1.53 ±3.29	-3.43 ±0.78	0.8	n.s.
Power [Watt/kg]				
PPO: peak positive	12.01 ±3.02	13.73 ±03.55	0.5	*
WA: peak negative Peak WA	-27.69 ±9.13	-32.60 ±11.47	0.5	*
Knee-Stiffness [mNm/deg.kg]	132.10 ±17.04	144.80 ±18.47	0.7	n.s.

* Denotes statistically significant and n.s. no significance difference between VR and NR (*P*< 0.05).

The ground reaction forces showed an increased peak F_z when blindfolded with a medium effect size (NR: 28.36 ±3.46 N/kg; VR: 30.78 ± 3.79 N/kg). The joint moments show opposing results. While the variables for the knee extension moment were significantly increased (Table 1) when blindfolded, the hip extension moment variables were significantly decreased (Table 2) in the blindfold condition. In more detail, cutting blindfolded was characterised by a significant increased peak extension moment in the knee (7.4 %) and a reduced peak extension moment in the hip (-15.9 %). Additionally, the knee peak power values showed a significant increased peak joint power absorption (15.0 %) and generation (12.5 %) (Table 1). In the sagittal hip joint power the significant difference indicated that participants were generating power during the PPO when unrestricted, but absorbed power by blindfolding (Table 2). While there was no change in hip joint-stiffness in the sagittal plane, higher sagittal knee-stiffness occurred when blindfolded with a medium effect size (8.8 %; d=0.7) (Table 1 and 2).

Table 2: Hip: Means (±SD) of peak and range of motion (ROM) and mean phase parameters (weight acceptance phase (WA) and peak push off (PPO)) for sagittal plane kinematic and kinetic variables for no restriction (NR) and visual restriction (VR)

Sagittal Plane Hip Variables	NR Mean ± SD	VR Mean ±SD	Cohen's d	Sign.
Kinematic [deg.]				
Peak hip flexion	54.8 ±13.2	49.3 ±09.0	0.4	n.s.
WA: mean hip flexion	50.0 ±11.7	43.4 ±09.9	0.6	n.s.
PPO: mean hip flexion	37.3 ±11.9	28.6 ±12.4	0.7	*
ROM	64.5 ±10.9	60.1 ±07.8	0.4	n.s.
Moment [Nm/kg]				
Peak Hip extension	-4.39 ±1.25	-3.69 ±0.92	0.6	*
WA: mean Hip extension	-2.46 ±0.90	-1.98 ±0.99	0.5	*
Power [Watt/kg]				
PPO: mean	3.51 ±3.82	-0.44 ±4.11	1.0	*
Hip-Stiffness [mNm/deg.kg]	91.88 ±17.91	94.26 ±22.63	0.1	n.s.

* Denotes statistically significant and n.s. no significance difference between VR and NR (*P*< 0.05).

DISCUSSION: The aim of this study was to investigate the differences in kinematics and kinetics in performing a cutting manoeuver blindfolded.

The statistical relevant changes in all computed parameters were found in the weight acceptance and the peak push off phase. Generally less flexion in hip and knee was found for performing a cutting manoeuvre under visual restriction. In combination with slightly altered vertical ground reaction force data, this could lead to a greater resistance of joint movement, which is underlined by a tendency to greater knee joint-stiffness in the sagittal plane. Similar results for F_z peak and knee flexion could be found when perform a drop jump blindfolded (Santello et al., 2001).The opposing development in the sagittal plane of knee joint moment and power (increase) to hip joint moment and power (decrease) however cannot be solemly explained by this. The combination of slight changes in joint angles, COP and orientation of the ground reaction force due to the visual restriction might lead to an increase in lever arm for the knee and decrease of lever arm in the hip. In the ankle the inversion angle at WA is the only statistically relevant variable though only a slight change occurred (1.3 ±0.3 deg.).

CONCLUSION: Players modify kinematic and kinetic movement patterns significantly when performing a cutting manoeuvre under restricted visual sense. Priority of reorganisation of the motor output when performing blindfolded seems the alteration of flexion in the hip and knee. In future studies kinematic and kinetic variables have to be selected with care when analysing a cutting manoeuvre without visual feedback. However in this study the spatial-temporal parameters approach velocity and contact-time does not interfere relevantly by restricting the visual sense.

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