IS TRUNK NEUROMUSCULAR CONTROL DIFFERENT BETWEEN MALES AND FEMALES DURING A CHANGE OF MOVEMENT DIRECTION?

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The purpose of this study was to evaluate the influence of gender and the cutting angle on trunk control and knee joint moments during cutting maneuvers. Male and female athletes performed unanticipated cuttings to 30° and 60°. Gender had no influence on trunk kinematics, muscles activation or knee joint moments. A sharper cutting angle increased trunk flexion ($p = 0.02$) and decreased trunk rotation away from the new movement direction ($p < 0.001$). Moreover, knee joint abduction moment was significantly increased ($p < 0.001$), together with altered trunk muscles co-contractions. In the early phase of the movement, the antagonist external oblique muscle appeared to work eccentrically. This might be useful to maintain the trunk lateral flexion at a certain level prior to initiate the trunk rotation towards the new movement direction.

KEY WORDS: core stability, cutting maneuver, knee abduction moment.

INTRODUCTION: During cutting maneuvers, the athlete performs a complex dynamic task to operate a quick change of movement direction (COD) while controlling his balance. During such movements, the control of the trunk is of interest as increased knee joint loading possibly stems from higher lateral trunk motion (Hewett & Myer, 2011). Indeed, the mechanical coupling between lateral trunk lean, hip joint abduction and knee joint abduction would theoretically explain why higher lateral trunk motion would increase knee joint loading. Moreover, it has been reported that female athletes had a greater trunk lateral lean than male athletes during COD situations leading to anterior cruciate ligament injury (Hewett, Torg & Boden, 2009). Therefore, deficits in trunk neuromuscular control in female athletes during COD might partially explain their higher risk of knee joint injury compared to their male counterparts. Despite recent studies having provided an analysis of trunk neuromuscular control during COD (Donnelly et al., 2015; Jamison, McNally & Chaudhari, 2013), little is known about gender specificities yet.
Among the different parameters influencing the execution of a COD, the cutting angle has been demonstrated to influence lower limb biomechanics (Dos'Santos et al., 2018). Specifically, sharper COD increased knee joint abduction moments during unanticipated cuttings (Sigward, Cesar & Havens, 2015). Interestingly, the latter study reported a trend for higher knee joint abduction moment for females compared to males at a 110° cutting angle while comparable values were found at 45° (Sigward et al., 2015). Therefore, gender-specific trunk neuromuscular control might be better teased out with respect to the degree of the cutting angle.
The purpose of the present study was to test to which extend, trunk neuromuscular control is different between male and female athletes and is influenced by the cutting angle during COD.

METHODS: Twelve male athletes (age: 24.2 ± 2.5 years old; height: 1.80 ± 0.06m; mass: 74.1 ± 8 kg) and twelve female athletes (age: 21.6 ± 1.4 years old; height: 1.67 ± 0.05m; mass: 59.3 ± 7.3 kg) participated in the study. All participants had at least 10 years of experience in their respective team sport (e.g. handball, soccer, basketball), and were therefore familiar with lateral movements.
Participants were asked to perform three different cutting tasks on a force plate (AMTI, Watertown, USA) in a randomized order, including a cutting maneuver to 30° to the left,

another to 60° and a crossover to -20° with an approach running speed of 4 ± 0.2 m.s^{-1}. Movement direction was indicated by a light signal occurring 460 ms before the right foot contacted the force plate. During the different tasks, 3D kinematics of the trunk and lower limb segments were recorded (Vicon, Oxford, UK). Surface electromyography recordings of core muscles were obtained from the rectus abdominis (RAB), the external oblique (EOB) and the erector spinae (ESP) of the right and left sides (Myon, Baar, Switzerland).
Kinematic data for the trunk and knee joint moments were analyzed at the time of the peak knee abduction moment (PKAM) during the 30° and 60° cutting maneuvers. All electromyographic data Root Mean Square (RMS) values were determined during the pre-activation (Pre) phase (100ms prior to the initial contact with the force plate) and during the weight acceptance (WA) phase (30ms after initial contact). The activation of the different muscles was then normalized to their peak filtered RMS value recorded during a running trial at 4m.s^{-1}. Directed Co-Contraction Ratios (DCCR) were calculated in order to provide directionality between agonist muscles during COD (i.e. left RAB, right EOB and left ESP) and their antagonists. Trunk kinematics was positive when orientated towards the new movement direction, i.e. a forward flexion, a lateral flexion and a rotation to the left while cutting to the left direction.
The selected parameters were averaged across ten trials. The influence of gender (Males vs. Females) and the cutting angle (30° vs. 60°) on the dependent variables was analyzed using a two-way ANOVA with repeated measures for the cutting angle. The level of significance was set at 0.05.

RESULTS: At the time of peak knee abduction moment, none of the trunk kinematics differed between Males and Females and knee abduction moment was not influenced by the gender condition (Table 1).

Table 1
Gender and cutting angle effects on trunk control at peak knee abduction moment

	Males		**Females**		Angle
	30°	**60°**	**30°**	**60°**	effect (p)
Trunk flexion (°)	7.9 ± 8.0	9.8 ± 6.9	8.7 ± 5.2	10.4 ± 5.1	0.02
Trunk lateral flexion (°)	-9.1 ± 4.4	-10.7 ± 4.9	-7.0 ± 2.5	-7.6 ± 3.4	NS
Trunk rotation (°)	-6.7 ± 8.4	0.6 ± 8.1	-13.5 ± 9.9	-4.7 ± 12.1	<0.001
PKAM (Nm.kg^{-1})	0.41 ± 0.28	1.06 ± 0.37	0.40 ± 0.25	1.03 ± 0.45	<0.001

However, trunk flexion and rotation were significantly influenced by the cutting angle, while trunk lateral flexion was not (Table 1). Moreover, knee joint abduction moment was significantly greater for 60° than 30°. No interaction effect was found for trunk kinematics or peak knee abduction moment.

Trunk neuromuscular control was not different between Males and Females (Table 2).

Table 2
Gender and cutting angle effects on the different muscles DCCR

	Males		**Females**		Effect
	30°	**60°**	**30°**	**60°**	
RAB Pre	0.15 ± 0.48	0.31 ± 0.50	-0.01 ± 0.51	0.24 ± 0.45	Angle
RAB WA	0.21 ± 0.47	0.25 ± 0.53	0.07 ± 0.49	0.10 ± 0.47	
EOB Pre	-0.03 ± 0.44	-0.38 ± 0.41	-0.05 ± 0.44	-0.32 ± 0.42	Angle
EOB WA	-0.47 ± 0.25	-0.46 ± 0.31	-0.25 ± 0.51	-0.45 ± 0.34	Interaction
ESP Pre	0.05 ± 0.33	0.29 ± 0.32	0.12 ± 0.49	0.19 ± 0.50	
ESP WA	0.53 ± 0.41	0.36 ± 0.45	0.39 ± 0.54	0.32 ± 0.57	Angle

Co-contraction ratio for rectus abdominis during Pre increased towards the agonist muscle, i.e. the left side, with increased cutting angle (p<0.001). Co-contraction ratio for external oblique during Pre increased towards the antagonist muscle, i.e. the left external oblique, at 60° compared to 30° (p<0.001). The same was true during WA, but for Females only (p<0.05). Finally, co-contraction ratio for erector spinae during WA was less directed towards the left agonist erector spinae at the highest cutting angle (p<0.05).

DISCUSSION: Trunk kinematics and its neuromuscular control were comparable between male and female participants. Peak knee abduction moment was also not significantly influenced by gender. As trunk control was comparable for both populations, the lack of peak knee abduction moment difference was not surprising (Hewett & Myer, 2011). These trunk kinematics results are in line with Havens & Sigward (2015), who tested cutting angles up to 90°. However Sigward et al. (2015) found a trend towards greater peak knee abduction moment at 110° for females. Thus, a possible gender influence on trunk and knee control during COD might only arise above 110°, which represent extreme COD situations. Another explanation for the lack of gender effect could be a homogeneous female group, where possible participants presenting an excessive knee abduction moment where not present (Sigward & Powers, 2007). Adding such a female profile in future analyses might reveal some discrepancies in trunk control.

However, increased COD cutting angle from 30° to 60° enhanced peak knee abduction moment. This result is in agreement with the literature (Dos'Santos et al., 2018). The larger braking phase at 60° compare to 30° induced higher trunk flexion values. The sharper cutting angle also induced a better trunk rotation towards the new movement direction in order to succeed in the COD. Trunk lateral flexion remained at the same level at 60° with respect to 30° to avoid even larger knee joint abduction moment. This had consequences in terms of neuromuscular control. Indeed, a sharper cutting angle led to rectus abdominis muscles co-contraction directed towards the new movement direction, together with negative co-contraction for external oblique and less co-contraction ratio for erector spinae oriented towards the new direction. As co-contraction ratio for external oblique was negative and trunk lateral flexion was away from the COD, left external oblique provided an eccentric contraction to limit trunk lateral lean excursion. Maintaining trunk lateral flexion seems to be the primary strategy at the expense of trunk rotation, which remained overall negative.

CONCLUSION: This study identified no difference between male and female team sport players in trunk kinematics and its neuromuscular activity. However, changes in trunk muscles co-contractions are required during sharper COD. Especially, external oblique muscles eccentric action in the early phase of the COD appears essential. Coaches and athletes seeking for better performance during COD could focus more on eccentric strengthening of these muscles.

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