# DOES ATHLETIC BACKGROUND INFLUENCE TRUNK NEUROMUSCULAR CONTROL DURING CUTTING MANEUVERS?

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The purpose of this study was to evaluate the effect of sports specificities on trunk neuromuscular control during cutting maneuvers. Male handball players and karatekas performed unanticipated cuttings, while trunk kinematics and muscles activation were measured. No significant difference in 3D trunk kinematics at initial contact between groups has been noted. Trunk peak angle values during weight acceptance were also comparable between groups. Trunk muscles co-contraction ratios during pre-activation and weight acceptance did not differ between handball players and karatekas. The lack of neuromuscular activity difference made sense with regards to the kinematic results. However, the use of muscles co-contraction ratios provided some information to further understand trunk control during cutting maneuvers. To conclude, high-level training, whatever the athletic background, seems to allow some skill transfer on unusual tasks, like cutting maneuvers.

**KEY WORDS:** Trunk control, Change of direction, Muscles co-contraction, EMG

**INTRODUCTION:** Knee joint injury risk, e.g. anterior cruciate ligament (ACL) rupture, depends on different factors including gender or the type of sports (Renstrom et al., 2008). During single leg drop landing, knee joint peak valgus has been reported to be higher for team sport female players than dancers (Orishimo et al., 2014). However, no difference in knee valgus moment and angle was found during a cutting task between soccer and basketball players (Cowley et al., 2006). Therefore, the influence of the sport specificity on knee joint control during various tasks associated with high knee joint loading remains unclear.

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; Jamison, Pan & Chaudhari, 2012). Therefore, knowing to which extend trunk neuromuscular control depends on athletic background would further help to understand the mechanistic connection between the trunk and the knee joint loading, and possibly ACL injury risk. On the one hand, studies have demonstrated the influence of the type of sports played on trunk control during unstable sitting tasks and trunk perturbations (Barbado et al., 2016; Glofcheskie & Brown, 2017), but information about sport-specific trunk neuromuscular control during tasks associated with high knee joint injury risk is lacking. On the other hand, recent studies provided an analysis of trunk neuromuscular control during change of movement direction (COD) (Donnelly et al., 2015; Jamison et al., 2013; Oliveira et al., 2012), but the effect of the sport specificity was not tested.

The purpose of this study was to test whether the athletic background influences trunk neuromuscular control during cutting maneuvers. We hypothesized that trunk position would be better orientated towards the new movement direction for handball players than karatekas and that trunk muscles activation would accordingly be different between groups.

**METHODS:** Nine male handball players (age: 21.3 ± 2.3 years old; height: 1.81 ± 0.07m; mass: 74.0 ± 9 kg) and nine karatekas (age: 28.0 ± 7.7 years old; height: 1.77 ± 0.05m; mass: 72.9 ± 5.9 kg) participated in the study. All participants had at least 10 years of experience in their respective sport. Handball players were playing at the non-professional national level and karatekas were black belt. The rationale for the choice of these two populations was to ensure two different expertises in the COD task, despite their respective

high level of sports practice and experience in their sport discipline. They did not have a previous history of serious knee injury or any current knee pain. Prior to testing, all participants were informed about possible risks and gave written informed consent.
Participants were asked to perform three different cutting tasks on a force plate (Bertec Corp, Columbus, Ohio) in a randomized order, including a cross-over to -20° to the left, a straight forward deceleration and a cutting maneuver to 45° to the right. The participants performed COD after a dynamic two step approach resulting in landing on the force plate with their left foot. Movement direction was indicated by a light signal triggered at the end of the two step approach to create an unanticipated COD paradigm. Kinematics of the trunk, based on the Lyon whole body biomechanical model (Tisserand et al., 2016), was captured in 3D at 100 Hz (SIMI Reality Motion Systems, Germany). Surface electromyography recordings (EMG) of the rectus abdominis (RA), the external oblique (EO) and the erector spinae (ES) of the right and left sides were recorded at 1000 Hz (Trigno™, Delsys, Natick, MA, USA). Data was only analyzed for the 45° cutting task to the right.
Marker trajectories were filtered with a low pass Butterworth filter (4th order, 15 Hz cut-off frequency). 3D kinematical data for the trunk at the Initial Contact (IC), as well as trunk angle peak value for flexion, lateral flexion and rotation during the Weight Acceptance (WA) phase were analyzed. EMG data was band-pass filtered with a Butterworth filter ($4^{th}$ order, 10Hz-500Hz). Then, EMG data Root Mean Square (RMS) values were determined during the pre-activation (Pre) phase (100 ms prior to IC) and during the weight acceptance (WA) phase. WA was defined as the period from IC to the first trough in the vertical ground reaction force. The activation of the different muscles was then normalized to their peak filtered RMS value recorded during maximal broad jumps (averaged over two trials). Directed Co-Contraction Ratios (DCCR) were calculated as follows:
If agonist mean EMG > antagonist mean EMG;

DCCR = 1 - antagonist mean EMG / agonist mean EMG

Else

DCCR = agonist mean EMG / antagonist mean EMG – 1

Due to the cutting direction to the right, agonists were RA right (RAr), EO left (EOl) and ES right (ESr). Antagonists were RA left (RAl), EO right (EOr) and ES left (ESl). DCCR were calculated for RA, EO and ES independently.
Trunk kinematics was positive when orientated towards the new movement direction, i.e. a forward flexion, a lateral flexion and a rotation to the right. Finally, contact time (CT) during the COD execution was calculated from the force plate data.

The selected parameters were averaged across six trials. The influence of the population was analyzed using an independent t-test of Student after having confirmed that the data followed a normal distribution (Kolmogorov-Smirnov) and verified the variance homogeneity via the Levene test. The level of significance was set at 0.05.

**RESULTS:** No significant trunk kinematics difference was observed between handball players and karatekas (Table 1).

**Table 1**
**Trunk kinematics at Initial Contact (IC) and Weight Acceptance (WA)**

| Variable | IC | | WA | |
|---|---|---|---|---|
| | Handball | Karate | Handball | Karate |
| Trunk flexion (°) | 11.5 ± 6.6 | 16.9 ± 5.8 | 11.1 ± 6.9 | 16.5 ± 5.8 |
| Trunk lateral flexion (°) | -11.0 ± 6.0 | -10.3 ± 6.7 | -13.3 ± 7.2 | -11.7 ± 6.9 |

| | | | | |
|---|---|---|---|---|
| Trunk rotation (°) | -5.2 ± 8.8 | 4.8 ± 16.4 | -6.0 ± 8.8 | 4.6 ± 16.4 |

EMG values for RA, EO, and ES muscles were not different between the populations (Table 2). DCCR were not different either, despite a tendency for DCCR_ES at Pre to be different (p=0.06).

**Table 2**
**Neuromuscular activity during the pre-activation (Pre) and Weight Acceptance (WA)**

| Variable | Pre | | WA | |
|---|---|---|---|---|
| | Handball | Karate | Handball | Karate |
| EMG_RAl (%) | 12.4 ± 8.3 | 23.7 ± 33.1 | 11.8 ± 8.9 | 22.4 ± 31.7 |
| EMG_RAr (%) | 8.8 ± 6.0 | 12.3 ± 13.0 | 10.9 ± 7.5 | 13.0 ± 14.0 |
| EMG_EOl (%) | 40.3 ± 26.2 | 30.5 ± 26.2 | 46.5 ± 25.3 | 39.0 ± 35.7 |
| EMG_EOr (%) | 19.2 ± 11.1 | 14.2 ± 9.8 | 26.2 ± 12.5 | 20.9 ± 14.4 |
| EMG_ESl (%) | 26.2 ± 16.4 | 16.5 ± 14.5 | 16.0 ± 8.9 | 14.4 ± 11.2 |
| EMG_ESr (%) | 9.6 ± 7.6 | 18.5 ± 18.8 | 17.4 ± 13.0 | 24.7 ± 24.7 |
| DCCR_RA | -0.12 ± 0.55 | -0.14 ± 0.49 | -0.06 ± 0.41 | -0.04 ± 0.55 |
| DCCR_EO | 0.33 ± 0.53 | 0.40 ± 0.33 | 0.32 ± 0.49 | 0.34 ± 0.29 |
| DCCR_ES | -0.56 ± 0.39 | -0.08 ± 0.61 | -0.09 ± 0.57 | 0.23 ± 0.44 |

CT for handball players (270 ± 50ms) and karatekas (286 ± 49ms) were not significantly different (p=0.52).

**DISCUSSION:** Although handball players had a larger experience in cutting maneuvers due to their level of experience in a sport dealing with COD, their trunk control did not differ from karatekas. Indeed, trunk 3D kinematics was comparable between the two populations, which would explain the lack of significant differences in muscles pre-activation and during the weight acceptance phase, or muscles co-contractions. These results are surprising because i) trunk control was supposed to be sport-specific (Barbado et al., 2016; Glofcheskie & Brown, 2017) and ii) the difference in athletic background between a martial art and a team sport could have triggered higher discrepancies in the COD execution compared to Cowley et al. (2006), who compared soccer and basketball players. Moreover, it has been reported that the level of expertise influences knee kinematics (Kipp et al., 2013) and knee moments (Sigward & Powers, 2006) during cuttings. Therefore, our results would suggest that differences in motor control between experts with different athletic backgrounds would be lesser than between novices and experts in a task-specific sport. This is also supported by the lack of difference in contact time between the two populations, suggesting comparable motor control, even during a specific task that could be found only in one of these sports.
While EMG RMS variables were not different, DCCR could further help to understand trunk neuromuscular control. Theoretically EO would be responsible for trunk lateral flexion and rotation. Therefore, an isolated activation of the EOl would rotate the trunk to right and

increase lateral flexion. In our setup, EOr contraction would limit trunk rotation to the right and limit lateral flexion. The positive DCCR_EO (EOl > EOr) would reflect a higher importance to initiate trunk rotation (with EOl concentric action) than to limit trunk lateral flexion (with EOr eccentric action). The DCCR_RA close to 0 indicates almost equal activation of both RA muscles. The large variations of DCCR_ES between phases (Pre and WA) and populations would need further investigation to be fully understood.
This study has some limitations. The first is the difficulty to ensure comparable expertise and athletic level for both groups. Another limitation might be the use of the two-step dynamic approach prior to changing direction, which is close to the field for handball players, but will not necessitate a large braking phase as it takes place during cutting maneuvers performed after a running approach.

**CONCLUSION:** This study identified no difference between handball players and karatekas in trunk kinematics and its neuromuscular activity. However, the use of co-contraction ratio underlined the function of external obliques during cutting maneuvers. Coaches and athletes could focus more on strengthening these muscles to limit trunk lateral flexion and improve trunk rotation towards the new movement direction. Moreover, whatever the athletic background, high-level training seems to allow some skill transfer on unusual tasks, like cutting maneuvers, questioning the impact of exercise variety to improve cutting performance.

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