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DOES TECHNIQUE CHANGE AFFECT MUSCULAR SUPPORT AT THE KNEE IN SIDESTEP CUTTING?

Alasdair R Dempsey[1,2], Bruce C Elliott[1] and David G Lloyd[1,2]

School of Sport Science, Exercise and Health, The University of Western Australia, Crawley, Western Australia, Australia[1]
Musculoskeletal Research Program, Griffith Health Institute, Griffith University, Gold Coast, Queensland, Australia[2]

Technique modification can reduce knee loads during sidestepping but its effect on muscular support has yet to be identified. Electromyography data was collected from ten muscles during sidestepping under planned and unplanned conditions, prior to and following training. Flexion/Extension and Medial/Lateral co-contraction ratios and total activation were calculated for pre-contact and weight acceptance phases. The only observed change due to training was unplanned tasks becoming more laterally dominated and planned tasks more medially. While significant these changes are non-functional as the ratios still represent high levels of co-contraction. Technique modification training should lower anterior cruciate ligament loads as it results in reduced knee moments but similar levels of muscular support, thus lowering the risk of injury.

KEY WORDS: Injury Prevention, Anterior Cruciate Ligament, Electromyography.

INTRODUCTION: Anterior cruciate ligament (ACL) injuries are a severe and debilitating injury which occurs with unfortunate regularity in sport. Luckily, from an injury prevention perspective, the majority of these injuries occur with no contact with an opposition player or implement, making them an ideal target for injury prevention (Cochrane et al., 2007). The ACL's primary function is to prevent anterior drawer of the tibia, however it is also loaded by valgus and internal rotation moments applied to the knee (Markolf et al., 1995). It has subsequently been argued in the literature that internal rotation and in particular valgus moments are required for injury (Cochrane et al., 2007, McLean et al., 2004). High levels of valgus and internal rotation loads have been identified in sidestep cutting tasks, increasing when the task is performed in an unplanned manner, reflecting actual injuries (Besier et al., 2001, Cochrane et al., 2007). While the loads experienced at the knee are greater than that able to be supported by the ACL on its own, athletes do not rupture their ACL each and every time they undertake a sidestep cut (Besier et al., 2001). While some of the load is absorbed by the other ligaments and bony structures in the knee much of it is absorbed by the muscles crossing the knee. This support can be readily measured in the laboratory by identify the co-contraction of muscles crossing the knee (Besier et al., 2003). This can further be refined to identify co-contraction directed to absorb a specific load such as a valgus load where comparing the muscles inserting on the medial side of the knee to those on the lateral side of the knee gives level of directed co-contraction (Besier et al., 2003). It has been proposed that interventions targeting ACL injuries should have balance, plyometric and technique components (Hewett et al., 2007, Lloyd, 2001). Recently it has been shown that technique is related to knee moments and that technique modification training is capable of reducing the valgus moment experienced during both planned and unplanned sidestep cuts (Dempsey et al., 2009, Dempsey et al., 2007). While this reduction in moment is, at face value, beneficial in terms of reducing an athlete's risk of ACL injury, if this reduction was accompanied by a reduction in the levels of muscular support at the knee this benefit may disappear. To date the effect of technique modification training on the muscular support of valgus loads has yet to be reported. This is the aim of this paper.

METHODS: During our previous study were we identify that technique modification training was capable of reducing valgus knee moments (Dempsey et al., 2009) we also collected electromyography (EMG) data from ten muscles crossing the knee. Briefly the methods were as follows. Nine male team sport athletes were tested twice, immediately prior to and following 6 weeks of technique modification training, which progressed from closed to open skills practice. Training was performed in small groups, twice a week with each session lasting 15 minutes. During training, which was performed by the one instructor, participants were given both oral and visual feedback for the designated technique goal. The visual feedback used TimeWARP (SilconCOACH, Dunedin, NZ) to provide immediate feedback on their sidestep cut technique together with reference videos of athletes performing cuts using the desired technique. Participants aimed to gradually bring the stance foot closer to the midline of the body, ensure the stance foot was neither turned in nor turned out, and to maintain an upright torso, with the torso facing in the direction of travel. The testing protocol was as follows. After adequate warm up and task familiarization, the participants were required to perform at least four successful trials of three manoeuvres; a straight run, a sidestep cut and a cross over cut, under two different conditions; planned and unplanned. The sidestep cut, which along with the cross over cut, were to 45° ± 5°. For this study only the sidestep cut trials were analysed, with the other trials retained to avoid anticipation of this manoeuvre during the unplanned tasks. Using a target board with three high intensity light emitting diodes, participants were given cues for one of the three tasks in both the planned and unplanned conditions. For the planned trials participants received the cue prior to the trial commencing. During unplanned trials participants were cued approximately 400 ms prior to reaching the force plate, the actual cue time was based upon their approach speed, the latter being monitored using infrared timing gates linked to custom software. EMG data was collected using a telemetry EMG system (Telemyo G2, Noraxon) from the following muscles: tensor facia latae, vastus medialis, vastus lateralis, rectus femoris, medial hamstrings, biceps femoris, sartorius, gracilis and lateral and medial gastrocnemius. This data was synchronised to the three dimensional motion data and force plate data using Vicon Workstation (VICON Peak, Oxford, UK). EMG was full wave rectified, filtered using a 4th order 6Hz low pass Butterworth filter and normalised to the maximum EMG occurring during planned run tasks (Besier et al., 2003). Flexion/Extension (FE) and Medial/Lateral (ML) co-contraction ratios were calculated such that 1 represented pure Flexion/Medial activation, 0 equal activation and -1 Extension/Lateral activation (Table1; Heiden et al., 2009). Total activation (TA) was also calculated for each ratio (Heiden et al., 2009). Mean co-contraction and TA were calculated for 50ms prior to foot strike (PC) and foot strike to the first trough in the vertical ground reaction force trace (WA). Four linear mixed models were performed to identify differences for both condition and time.

Table 1: Muscle Groupings

	Medial	Lateral	
Flexors	Medial Hamstrings Medial Gastrocnemius Gracilis Sartorius	Biceps Femoris Lateral Gastronemius	
Extensors	Vastus Medialis	Vastus Lateralis Tensor Facia Latae	Rectus Femoris

RESULTS: There were no observed differences during the pre contact phase, nor were there any observed differences for total activation for either ratio during weight acceptance. All the values presented in the text from here are co-contraction ratios. During weight acceptance there was no time effect for the FE co-contraction ratio however unplanned tasks were more extensor dominated (-0.296) than planned sidesteps (-0.098). Similarly there was no main effect observed during weight acceptance for the ML co-contraction ratio however there was an interaction effect. Both tasks initially had perfect co-contraction (-0.16 Planned and 0.88 Unplanned) with planned tasks becoming medial dominated (0.133) and unplanned tasks becoming lateral dominated (-0.152) (Figure 1).

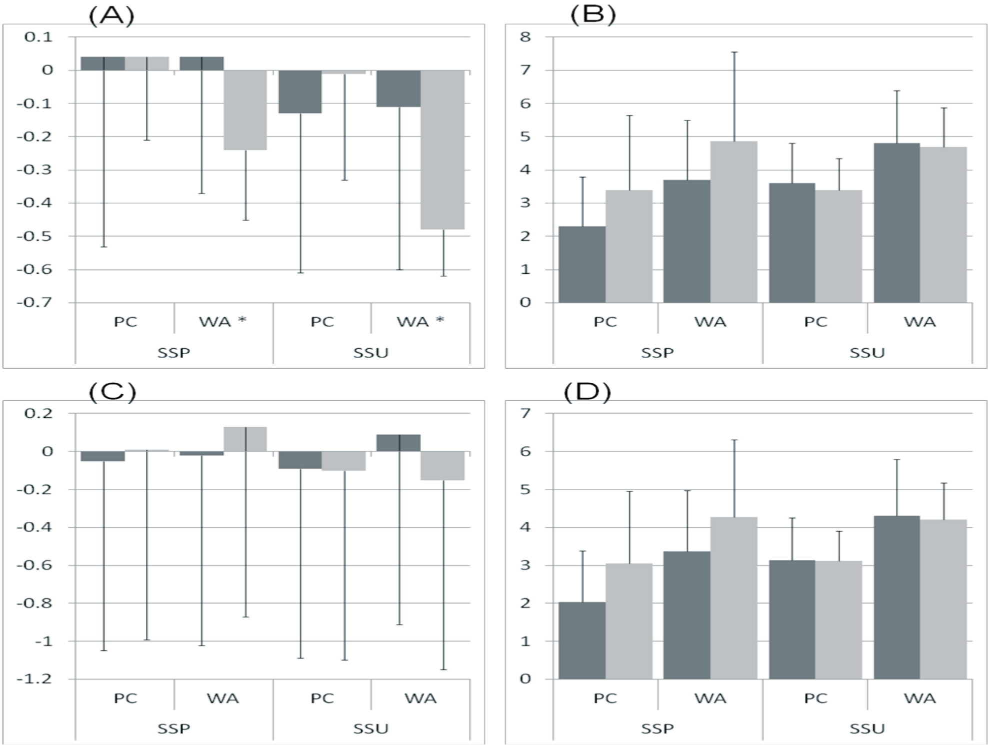

Figure 1: FE (A) co-contraction ratio, & (B) total activation, and ML (C) co-contraction ratio, & (D) total activation. The values in B and D are sum of normalised EMG values (Dark Columns - Pre Training; light columns - Post Training) (* $p<0.05$).

DISCUSSION: This study aimed to identify if the reduction in knee valgus moments observed following technique modification training was accompanied by a change in the levels of muscular support at the knee. The only observed time effect was a difference in the ML direction of support between planned and unplanned sidestep cuts. However as all values were maintained between -0.2 and 0.2 this difference, while significant, may not be a functional difference. Values between -0.2 and 0.2 represent high levels of co-contraction and therefore the support provided by the muscles will protect against both valgus and varus loads. Importantly the total level of support did not change across sessions with TA levels not significantly different. In fact while non-significant the observed trend was for an increase in the level of TA following training, suggesting an increase in the level of muscular support. Combining the lack of change in muscular support with the previously reported reduction in valgus moments following technique modification training, suggest, for sidestep cutting, that this form of training may be successful in reducing the risk of non-contact ACL injuries (Dempsey et al., 2009). Previously it has been postulated that technique programs should include technique, plyometric and balance components (Lloyd, 2001). Hewett et al. (2007) stated that the "…most effective and efficient [ACL injury prevention] programs appear to require a combination of components…". This is most likely due to the differnt compoents complementing each other, providing additional benefits. Balance and plyometric training have both been shown to be able to increase the levels of muscular support in sidstepping and landing tasks (Cochrane et al., 2010, Lim et al., 2009). The addtion of either of both of plyometrics and balance to technique modification training may result in increased muscular support accomining the decreases in valgus moments. This has the potential to dramatically reduce the loads being experianced at the ACL and therefore the risk of injury.

CONCLUSION: There was no reduction in muscular support at the knee during sidestep cutting following technique modification training. As previously it has been identified that there is a reduction in knee valgus moments following training this would suggest that technique modification training is capable of reducing the risk of non-contact ACL injuries.

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