MEASURING ADDUCTOR MUSCLE ACTIVITY DURING PASSING AND 90°-CUTTING TO INVESTIGATE THEIR ROLE IN THE DEVELOPMENT OF GROIN INJURIES

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Cutting manoeuvres and inside passing are thought to increase the risk of groin injuries, but research provides only little information in this regard. The purpose of the study was to compare the muscle activation of gracilis and adductor longus during a 90°-cutting manoeuvre and inside passing. Thirteen male soccer players performed the two movements. Muscle activity was measured with surface electromyography. Cutting showed higher maximum activations compared to passing in all investigated muscles. Activation during passing was high when considering that it is a submaximal effort with high amounts of repetition during match and training. Cutting showed the highest adductor activity during movement phases requiring eccentric contraction. Therefore, both movements are likely to put high loads on the adductor muscles and thereby increase the risk of groin injuries.

KEYWORDS: Soccer, Change of direction, Ultrasound, EMG

INTRODUCTION: Groin injuries like adductor strains and osteitis pubis are a common problem in sports where kicking and change of direction manoeuvres are key movements (Arnason, Sigurdsson, Gudmundsson, Holme, Engebretsen & Bahr, 2004; Serner, Tol, Jomaah, Weir, Whiteley, Thorborg, Robinson & Hölmich., 2015). While it is widely accepted that the above mentioned movements, if practised often, are risk factors for the development of groin injuries (Maffey & Emery, 2007), the literature offers only few studies investigating the underlying biomechanical mechanisms of groin injuries.
A study on soccer inside passing has shown that especially the gracilis muscle undergoes high stress during the swing phase (Dupré, Funken, Müller, Mortensen, Lysdal, Braun, Krahl & Potthast, 2018a). This stress is also transferred to the passive structures in the groin, making not only the muscles but also the whole groin area prone to overuse injuries. Studies on cutting manoeuvres have shown only inconclusive results regarding the connection of cutting manoeuvres to groin injuries (Edwards, Brooke & Cook, 2017; Franklyn-Miller, Richter, King, Gore, Moran, Strike & Falvey, 2017). One of our previous studies, using inverse dynamics to calculate adductor muscle forces during a 90°-cutting manoeuvre (CM), concluded, that the maximum muscle forces were lower than those calculated for inside passing (IP) (Dupré, Vincent, David & Potthast, 2018b). Thus, the role of CM in the development of groin injuries remains unclear. Understanding the muscular activation in the adductor muscles during CM and IP would enhance the knowledge regarding the load on the groin area during these movements and would provide insight towards injury prevention. Therefore, the purpose of this study was to investigate the muscle activation of the adductor longus and gracilis muscle during a CM and submaximal IP.

METHODS: Thirteen male participants (22 ± 3.29 years, 1.8 ± 0.06 m, 78.17 ± 7.21 kg) were tested in a laboratory of the German Sport University Cologne for this study. The electromyography (EMG) measurement was prepared according to SENIAM standards. Electrodes were placed on the muscle bellies of Gracilis and Adductor Longus. The adductor muscles were located using an ultrasonic device (Prosound Alpha 7, Aloka GmbH, Meerbusch, GER) (Watanabe, Katayama, Ishida & Akima, 2009). To normalize the muscle activity, a static, maximum voluntary contraction (MVC) was recorded as reference. Participants lay on their back with the knees bend 90°. A static resistance, fixing the between thigh angle to ≈45° was placed between their legs. Participants then had to push against the resistance as hard as possible.

EMG data was collected at 1000 Hz (Aktos, Myon, Schwarzenberg, CH). The testing was performed on third-generation artificial turf (LigaTurf, Polytan, Burgheim, Germany) to produce a real world equivalent shoe to ground interaction. Two 90x60 cm force plates, embedded in the ground, were used to collect ground reaction forces at 1000 Hz (Kistler, Winterthur, CH). All participants wore their own shoes. They had to perform five valid CM to the left with their right foot on force plate one (Figure 1, A) as fast as possible. 90°-cutting was investigated, as it produces higher loads than other cutting angles and is therefore more likely to be connected to injuries (Dupré et al., 2018b). IP was investigated by using a ramp to accelerate the ball to a velocity of 3 m/s. Participants were instructed to stand on force plate two and move one step towards the rolling ball when it left the ramp and perform an inside pass towards a target in front of them (Figure 1, B) with an intensity similar to passing towards a player 15 m away from them during a match. Thereby, participants performed the inside pass in a forward motion similar to a playing situation. The intensity of IP was not recorded. Five valid IPs were collected for each participant.

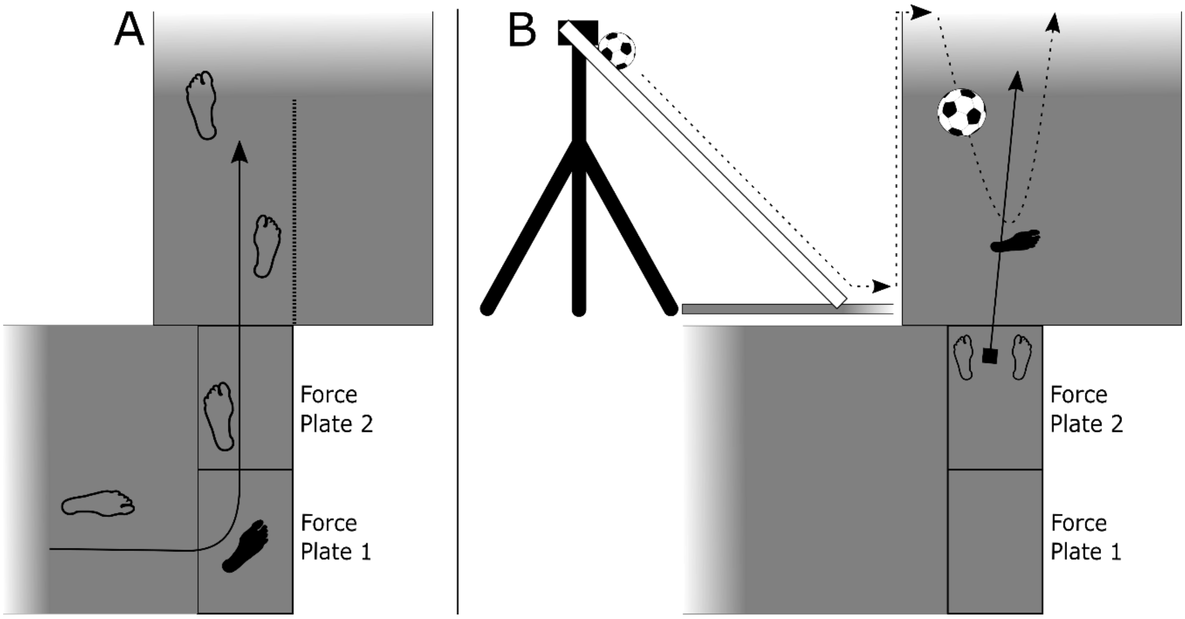

Figure 1: (A) presents the setup used for CM. Participants started from the left and had to place their right foot on force plate 1 and their left foot on force plate 2. (B) presents the setup for IP. Participants were allowed one step forward towards the ball and had to perform the pass with one ball contact towards a given target.

The data analysis was performed in Matlab 2019a (The MathWorks, Natick, Massachusetts). EMG raw data was filtered with a recursive 2nd order Butterworth band-pass filter with cut-off frequencies at 20 and 400 Hz. Based on the rectified signal the activation envelope was extracted with a recursive 2nd order Butterworth low-pass filter with a cut-off frequency of 6 Hz. Each muscle's activation was normalized to a corresponding MVC reference trial. CM trials were time normalized to the force plate contact of the right foot. The IP trials were time normalized to the swing phase, which was defined as toe-off of the kicking leg to ball contact. Maximum activation was extracted from every trial and used to create every participant's mean maximum activation for each of the two movements.
Shapiro-Wilk tests were used to test for normality. As this was given for all parameters, paired-sample, two-tailed T-tests were used to test for statistically significant differences. The alpha level was set to $\alpha = 0.05$.

RESULTS & DISCUSSION: The purpose of this study was to compare muscle activation of two adductor muscles between CM and IP. As can be seen in Table 1, both muscles showed a significantly higher mean maximum activation during CM compared to IP. Gracilis reached more than 100% MVC during CM showing the difficulties of collecting MVCs for dynamic movements with a static maximum contraction. Due to the muscle activity reaching more than 100%, comparing the activation of the two muscles with each other is omitted in this study. The average movement duration was 295.3 ± 41.9 ms for CM and 237.6 ± 69.4 ms for IP.

Table 1: Mean maximum activation (% MVC ± STD), P-values, T-values and degrees of freedom for the comparison between CM and IP of 13 participants for the two investigated muscles.

	Gracilis	Adductor Longus
CM	104 ± 37	53 ± 18
IP	39 ± 29	38 ± 15
p-value	<0.001	0.003
T-value	5.5913	3.6682
Degrees of freedom	12	12

A comparison of the muscle activity recorded for the two adductor muscles with modelled activity from a previous study shows a high similarity of the activation curves of gracilis during CM and its modelled activation (Dupré et al., 2018b). The activation curve of adductor longus is less similar to the modelled activation from the previous study but shows the same reduced activation during mid stance as shown in the previous study. This indicates that the adductor muscles experience the highest activation towards the end of the stance phase. This contradicts previous research where the highest activation was found during the weight acceptance phase (Chaudhari, Jamison, McNally, Pan & Schmitt, 2014). These discrepancies might be explained by differences in data processing as Chaudhari et al. calculated a mean activation for five movement phases which would likely smoothen out short peaks of high muscle activation. It is reasonable that the adductors show only low activation during mid stance of the CM: During mid stance, the external adduction moment requires high activation of the abductor muscles but not of the adductor muscles (Dupré et al., 2018b). High activation during terminal stance is needed to adduct the leg towards the body in preparation for the next step. This is likely to require high amounts of eccentric muscle contraction as the leg is in an abducted position during this phase of the CM (Dupré et al., 2018b). Due to the eccentric contraction and high muscle activity, it is likely that most adductor injuries happen during terminal stance as speculated in previous studies (Serner, Mosler, Tol, Bahr & Weir, 2018). For IP, Figure 2 shows the highest mean activation for adductor longus in the middle of the swing phase which is in line with findings from adductor force modelling for IP (Dupré et al., 2018a). Gracilis on the other hand shows the highest mean activation at the beginning of the swing phase. This can be explained with its function as a knee flexor additionally to being a hip adductor. The knee is flexed during the back swing phase (Levanon & Dapena, 1998) requiring gracilis activity. During acceleration phase, the need for knee extension might inhibit a higher gracilis activation.

Contrary to results from muscle force calculation, adductor muscle activity during CM was significantly higher compared to IP (Dupré et al., 2018b). Because IP is only performed with a submaximal effort, less muscle activation than during a full effort CM could be expected. Nevertheless, maximum adductor longus activation during the IP is 71.7% of the maximum activation experienced during CM. If it is considered that the IP is a highly repetitive movement (Rahnama, Reilly & Lees, 2002) this might still put the adductor longus under considerable load as it has already been indicated by a modelling approach (Dupré et al., 2018a). Nevertheless, further studies are needed to clarify the contradictory results found for gracilis.

The most important limitation of this study was the use of surface electrodes to collect adductor muscle activity. Especially the gracilis provides only a small area of skin for the electrodes due to its small size. Therefore, crosstalk from adjacent muscles cannot be ruled out although the use of sonography should have provided a high accuracy during electrode placement.

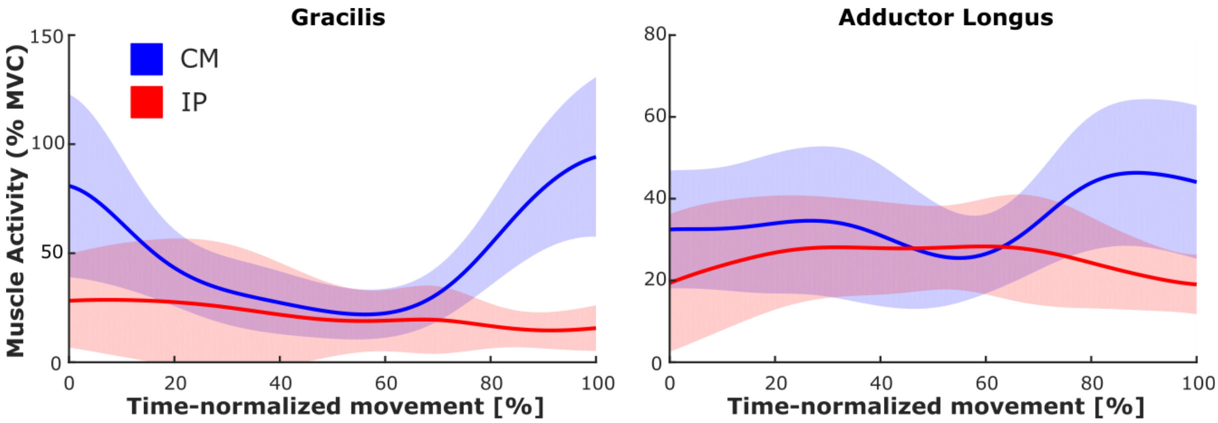

Figure 2: Mean activation curves of the investigated muscles from 13 participants for CM and IP relative to the measured MVC values and ± standard deviation. The curves are presented as time-normalized to the stance phase during CM and the swing phase during IP.

CONCLUSION: CM shows a higher maximum activation than IP. Nevertheless, as IP is often performed as a submaximal effort with high amounts of repetition, groin injuries might develop as a result of accumulating loads. Both movements are likely to increase the risk for groin injuries with high amounts of repetitions as supposed by the literature. Practitioners should keep this in mind during training and refrain from sessions involving high quantities of CM or IP.

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