JOINT MOMENTS DURING INSTEP KICKS IN FOOTBALL PLAYERS WITH AND WITHOUT PREVIOUS GROIN PAIN

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This study examined how previous groin pain and approach angle affects stance leg and lumbar moments during instep kicks. Male football players with and without previous groin pain (n=11, and n=10) performed instep kicks from 45° and 60° angles while kinetic and kinematic data were recorded (1000Hz and 500Hz respectively). 3D stance leg net joint moments of the hip, knee, and ankle were calculated at peak swing knee flexion and ball contact and the sagittal L5/S1 joint moment was examined throughout the kick. Foot speed at ball contact indicated performance. Players with previous groin pain had lower moments during the kick compared to uninjured controls, but there was no difference in performance. This suggests that the players with previous groin pain utilized an aberrant kicking pattern that offloads certain joints but may cause compensations elsewhere in the kinetic chain.

KEYWORDS: soccer, performance, compensation, aberrant mechanics, injury.

INTRODUCTION: Groin pain is one of the most common injuries among football players and is particularly difficult to diagnose due to vague symptomatology (Werner, Hagglund, Walden, & Ekstrand, 2009). Pain is typically associated with altered movement patterns as protective mechanisms act to prevent further tissue damage (Coffey, Harrison, Donoghue, & Hayes, 2011). While the literature on biomechanical consequences of previous groin pain is scarce, one study showed aberrant hip and pelvic kinematics during instep kicks in football players with previous groin pain (Severin, Mellifont, & Sayers, 2016). The study also showed a reluctance to adapt to task constraints (an altered approach angle) in players with previous pain. Despite this indication that aberrant kicking mechanics can remain after pain has resolved, and the player is considered rehabilitated, limited research has built on this important observation. The previous study reported only on kinematics, and provided no data on joint kinetics, which would allow an increased understanding of how previous pain may affect the task mechanics. The kinetic profiles of the stance leg and lumbar spine are of particular interest during forceful kicks, due to the stabilising role of the stance leg (Inoue, Nunome, Sterzing, Shinkai, & Ikegami, 2014), and the contribution of the upper body's 'tension arc' for kicking performance (Lees, Asai, Andersen, Nunome, & Sterzing, 2010). Therefore, this study aimed to (1) assess the effects of previous groin pain on stance leg and lumbar flexion joint moments during football instep kicks and to (2) examine the effects of task constraints on these data by altering approach angle.

METHODS: Eleven semi-professional male football players with previous non-specific groin pain (PGP) (1.77±0.05 m, 73±6 kg, 23±5 years), and ten matched Controls (1.77±0.05 m, 74±4 kg, 24±4 years) volunteered to participate. For the PGP group, inclusion criteria ensured that all players had missed training and/or games due to some form of groin pain during the past 12 months but were pain-free at the time of testing. Due to acknowledged difficulty in diagnosing the cause of groin pain, any type of groin pain was included in this study. The Control group had never experienced groin pain and were free from lower extremity injury in the 3 months prior to testing. All participants provided written informed consent before any testing. Kinematic data were collected and processed as per the paper by Severin et al. (2016), where trunk and lower body kinematics were collected at 500Hz using a motion capture system (Qualisys AB, Gothenburg, Sweden), and kinetic data were collected (1000Hz) using force platforms (Bertec, Columbus, OH, USA). Markers were also placed on a size-5 football to identify ball contact (BC). Participants performed six kicks using their preferred leg from a 45° and 60° approach angle (Scurr & Hall, 2009) in a randomized order.

The data were processed using Visual3D (C-motion, Inc., Rockville, MD) with a low-pass filter of 15 Hz (Severin et al., 2016). Joint moments of the stance hip, knee, and ankle were normalized to body weight and extracted at peak knee flexion (PKF) of the swing leg, which marks the end of the leg cocking phase (Nunome, Asai, Ikegami, & Sakurai, 2002), and at BC. The net 3D joint support moments (NJM) were calculated from the individual contributions of the three joints using standard techniques (Peterson & McNitt-Gray, 2018). The relative contribution from each joint was expressed as a percentage of the total NJM. Sagittal plane joint moment (about the global x-axis) of the L5/S1 joint was calculated according to Seay, Selbie, and Hamill (2008), with respect to the pelvis and time-normalized to 101 data points for the duration of the kick (from peak knee flexion to peak hip flexion of the swing leg). Between-group differences in peak lumbar flexion moment, total NJM, and absolute (Nm/kg), and relative (%) contribution from the hip, knee, and ankle were identified with independent samples t-tests (alpha level 0.05) and Cohen's d indicated effect size (<0.5 *small*, 0.5-0.8 *moderate*, and >0.8 *large)*(Cohen, 1988). Swing foot speed at BC indicated performance.

RESULTS: Foot speed at BC did not significantly differ between the groups (45°: Control: 18.9±1.6 $m{\cdot}s^{-1}$, PGP 18.8±1.6 $m{\cdot}s^{-1}$, p=0.848, d=0.09, 60°: Control: 18.7±1.7 $m{\cdot}s^{-1}$, PGP 17.5±1.7 $m{\cdot}s^{-1}$, p=0.135, d=0.72). The peak lumbar flexion moment differed between the groups at both the 45° (Control: 2.7±0.7 Nm/kg, PGP: 1.9±0.6 Nm/kg p=0.009, d=1.1), and 60° approach (Control: 2.6±0.5 Nm/kg, PGP: 1.7±0.4 Nm/kg p=0.001, d=1.4) (Figure 1).

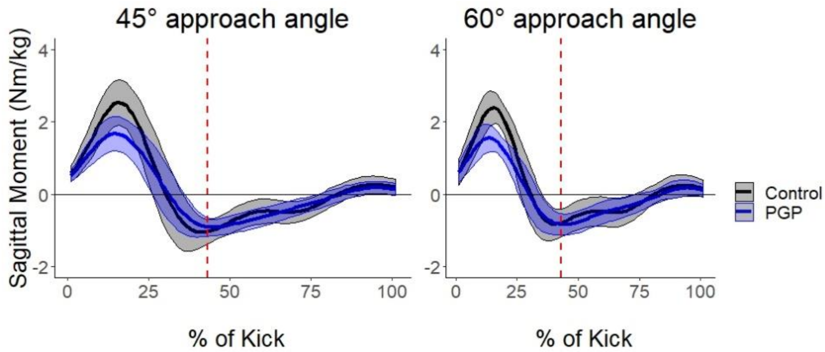

Figure 1: Sagittal plane lumbar moment normalized to body weight during the instep kick during 45° and 60° approach angles. Shaded area is 95% CI, red line represents ball contact.

At PKF, a large effect size during the 60° approach, and a moderate effect size during the 45° approach suggested the PGP group produced smaller total NJM, though not to a significant level (Figure 2). The absolute contribution from the hip joint was significantly lower for the PGP group during kicks from the 60°, though large effect sizes suggested less contribution during both approaches.

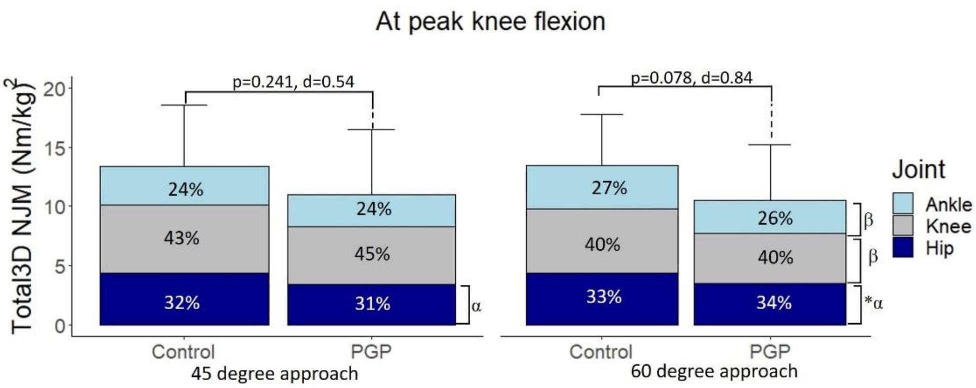

Figure 2: Total stance leg NJM at peak knee flexion for the two approach angles. Stacks height indicate absolute (Nm/kg) joint contribution and percentages indicate relative (%) joint contribution, *p<0.05, α: d>0.8, β: d>0.5 for between-group comparisons.

At BC, the analysis showed similar non-significant reductions in the total NJM that were seen at PKF in the PGP group, with large effect sizes at both approach angles (Figure 3). Significantly lower absolute contributions from the ankle joint were seen in the PGP group at both approach angles, while non-significant moderate effect sizes showed lower contributions also from the hip and knee joints in the PGP group. No within-group differences existed in total NJM or absolute contribution between the approach angles (p>0.483, d<0.32), or in the relative (%) contribution between groups (p>0.532, d<0.23).

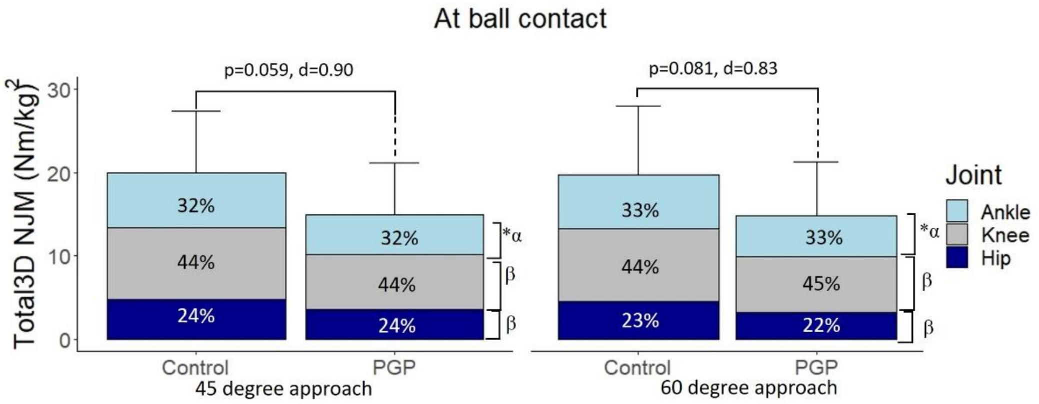

Figure 3: Total stance leg NJM at ball contact for the two approach angles. Stacks height indicate absolute (Nm/kg) joint contribution and percentages indicate relative (%) joint contribution, *p<0.05, α: d>0.8, β: d>0.5 for between-group comparisons.

DISCUSSION: Key findings from this study included that players with previous groin pain had lower peak L5/S1 flexion moments during the kick and that they appeared to generate notably lower total NJM about their stance leg at the time of PKF and BC, as indicated by the moderate and large effect sizes, despite not reaching statistical significant difference.

The lower L5/S1 flexion moment in the PGP group at both approach angles suggests a reduced reliance on trunk flexion for generating momentum during the kick, which potentially can be associated with the lower sagittal plane pelvic motion and peak velocity in players with previous groin pain (Severin et al., 2016). Despite these reduced lumbar moments, we did not observe reduced kicking performance in our participants as indicated by the foot speed at BC. Lees et al. (2010) highlighted the importance of the trunk for kicking performance in creating a ‘tension arc’ through hip-shoulder separation. However, this hip-shoulder separation involves all three planes of motion, so it is possible that increased lumbar spine moments in the frontal and transverse plane compensated for the reduced sagittal plane moments.

The lower total NJM for the PGP group may indicate reduced control of the ground reaction forces about the stance leg (Peterson & McNitt-Gray, 2018). Kicking is a complex task that requires intersegmental control, so reduced control about the stance leg can theoretically have detrimental effects on performance and may contribute to compensatory injuries. Similar to the lower trunk moments, this reduced control was not reflected in the performance, which can be a further indication of compensatory movement strategies elsewhere in the kinetic chain.

At PKF, the lower total NJM in the PGP group was predominantly a function of lower absolute contribution of the hip joint. PKF occurs during the late cocking /early acceleration phase, when the stance limb works to both stabilize the body against the forces associated with the kicking action, and transfer energy to the swing limb (Inoue et al., 2014). The stance leg hip joint has a considerable role in both these tasks, so its lower contribution further suggests compensations at other joints in the kinetic chain in order to maintain performance. However, it remains unclear where these may occur as this analysis did not reveal any such compensations.

At BC, it was predominantly less contribution from the ankle joint that resulted in the lower total NJM in the PGP group. While it has been shown that greater hip and knee extension moments of the stance leg prior to BC contributes to swing leg velocity (Augustus, Mundy, & Smith, 2017; Inoue et al., 2014), little research has reported on the role of the ankle. Figures 2 and 3 show that both the absolute and relative contribution of the ankle joint was larger than that of the hip at BC for both groups. This suggests an important role of the ankle joint, likely to assist in knee extension through maintaining the shank vertical (plantarflexion) and help maximize the energy transferred from the ground to the swing foot.

Interestingly, despite lower total NJM and absolute contribution from the different joints, the relative contributions (i.e. %) did not differ between groups. This is encouraging as it suggests that the inter-joint coordination was similar between the groups during the kicks. Inter-joint coordination is important for kicking performance (Lees et al., 2010) and maintained coordination may reduce the risk of subsequent injury.

Further, the moments did not change with the approach angles, which suggests that changing the approach from 45° to 60° has little effect on the stance limb moments in both groups. However, since previous research has showed altered kinematics in these populations (Severin et al., 2016), it is possible that these torques may be applied to the joint in different positions (i.e. different position on the force-velocity curve), contributing to unfavourable loading of the hip/groin complex. More comprehensive studies are needed to understand how these altered mechanics affect players in the long-term in terms of performance and injury risk.

CONCLUSION: This study showed that football players with previous non-specific groin pain produce lower peak flexion moments at the lumbar spine and non-significantly lower total 3D NJM about their stance leg during maximal instep kicks. While all joints of the stance leg contribute to this non-significantly lower NJM, this study suggested that it was the hip and ankle that had the largest effects at peak knee flexion and ball contact, respectively. Combined, the findings from this study suggested that the PGP group demonstrated a kicking technique with altered trunk involvement and stance leg control, perhaps as a risk mitigating adaptation to being previously exposed to groin pain. The relative joint contributions from the hip, knee, and ankle were similar to the control group which suggests a maintained inter-joint coordination pattern in the stance leg of the PGP group. Since the foot speed did not suggest a performance deficit in the PGP group, it is likely that the aberrant kicking technique had resulted in compensations elsewhere in the kinetic chain. Further research is needed to identify these potential compensations and identify any long-term consequences of this aberrant kicking technique and whether it precedes initial onset of groin pain.

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