Instituto Universitario de Investigación de Ingeniería de Aragón
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XIV JORNADA DE JÓVENES INVESTIGADORES/AS DEL I3A

Differences in Kinematic and Muscle Activity Associated with ACL Injury Risk in Second Division Female Football Players

Influence of Limb Condition and Change of Direction Task

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INTRODUCCTION

0.7 injuries per squad per season and **0.1** injuries per 1,000 hours of play

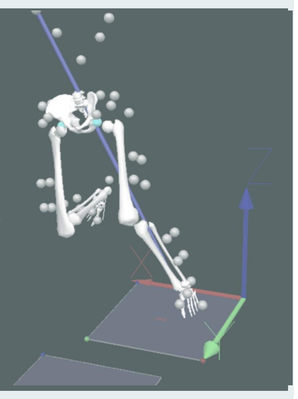
Clinical severity and Long-term impact

- **38** days lost per 1,000 hours of exposure
- **117** days of recovery
- **25-35%** of players face re-injury within 2-5 years
- **only 81%** returning to their prior competition level

Valgus Collapse
(Hip internal rotation and adduction and knee abduction)
Incorporate transverse plane function.

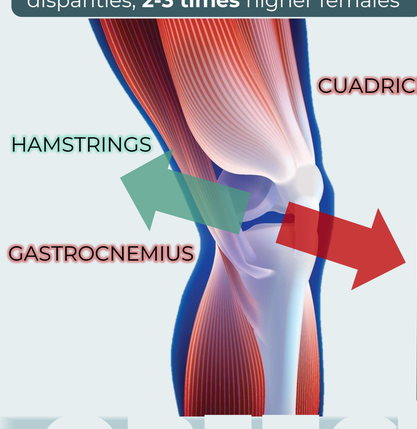
Excessive transverse plane movement may be the primary ACL risk factor
(No consensus internal or external tibial rotation)

KINEMATIC



Persistent sex-related prevalence disparities, **2-3 times** higher females

IDENTIFY RISK FACTORS



MUSCLE ACTIVITY

94% ACL Stabilization occurs in Sagital Plane

HAMSTRINGS
ACL synergist by counteracting anterior tibial translation during sidecutting stabilization maneuvers.

Semitendinosus (ST)
'Knee adductor', contributing to medial joint compression preventing valgus collapse

QUADRICEPS
Increase anterior shear forces and places strain on the ACL

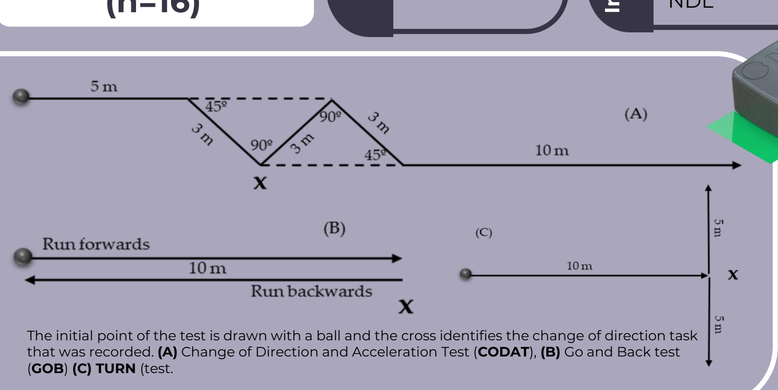
GASTROCNEMIUS
Posterior displacement of the femur that may contribute to anterior tibial translation

METHODS

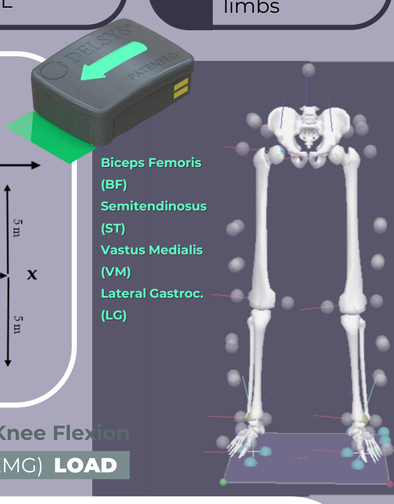
PARTICIPANTS (n=16)

Injured Dominat Limb (InjDom)	Sustained a previous non-contact knee injury involving valgus collapse without ACL rupture or surgical in DL
Injured Dominat No Limb (InjNDom)	Sustained a previous non-contact knee injury involving valgus collapse without ACL rupture or surgical in NDL
Healthy Control (Healthy)	Injury free and had not previously sustained a knee injury DL were computed no significant differences between limbs

CHANGE OF DIRECTION TEST
InjDom and **Healthy DL** as the stance limb
InjNDom group used their **NDL** as the support limb

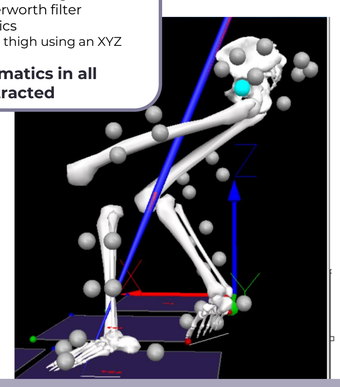


The initial point of the test is drawn with a ball and the cross identifies the change of direction task that was recorded. **(A)** Change of Direction and Acceleration Test (**CODAT**), **(B)** Go and Back test (**GOB**) **(C) TURN** (test.



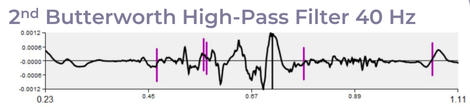
DEFINED PHASES
100 ms | Initial Ground Contact | Maximum Knee Flexion
PREP LOAD (EMG) | (Kinematic + EMG) **LOAD**

KINEMATIC DATA
Filtered by 4th order zero-lag 8Hz low-pass Butterworth filter
Knee joint kinematics (shank relative to the thigh using an XYZ cardan sequence)
Peak knee kinematics in all planes were extracted

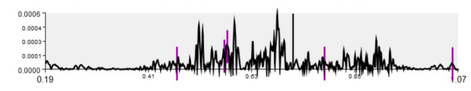


MUSCLE ACTIVITY (EMG) DATA

2nd Butterworth High-Pass Filter 40 Hz



Full wave Rectified => AVERAGE EMG



Low-Pass Filter 15Hz => PEAK ENVELOPE EMG

DATA ANALYSIS

OBJECTIVES

1

First objective was
Evaluate angular velocity and joint angle kinematics of the knee,
as well as
Muscle activity in hamstrings, quadriceps and gastrocnemius,
in players at risk of ACL injury and healthy players
during three sidecutting tests

2

Evaluate how the amplitude, change of direction and limb dominance influence the stabilization pattern of the player

RESULTS

KINEMATIC

Kinematic differences are better reflected in **angular velocity** rather than peak joint angles

InjDom higher ACL injury risk than **InjNDom** in all planes or **Healthy** in transverse plane

InjDom players demonstrated greater angular velocities in sagittal, frontal and transverse planes.

This Suggest:

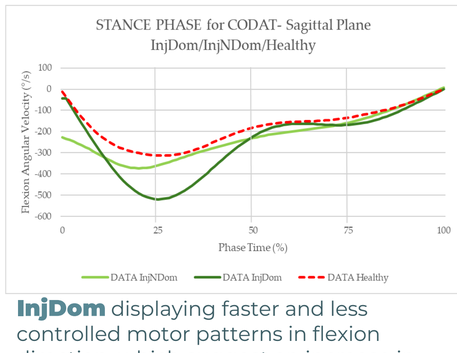
Most kinematic differences are better reflected in angular velocity rather than peak joint angles, which only reached statistical significance between the InjDom and Healthy groups in the transverse plane.

While InjDom and InjNDom players exhibited similar knee angles during the LOAD phase, InjDom players reached these angles at significantly higher angular velocities.

This may reflect a less controlled motor pattern in **InjDom** players, resulting in faster adjustment movement. In contrast, **InjNDom** players have similar angular velocities to **Healthy** group, suggesting more controlled motor patterns with less reliance on rapid adjustments.

SAGITTAL PLANE

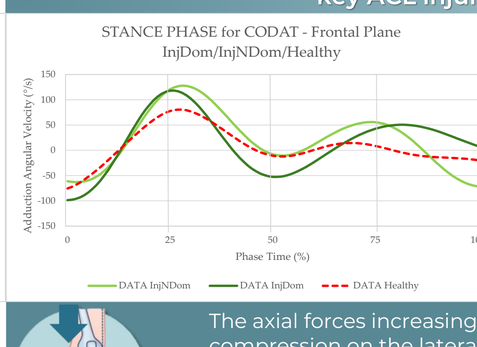
InjDom exhibited significantly **higher flexion-extension range of motion** and **flexion angular velocity,** most of these differences are concentrated within the **first 25% of the LOAD phase.**



InjDom displaying faster and less controlled motor patterns in flexion direction, which suggest an increase in knee stabilization demands. This reduced control may contribute to increased ACL loading, due to the main peak in ACL force occurring at approximately 14% of the LOAD phase, with over 94% of the ACL force generated in the sagittal plane.

CORONAL PLANE

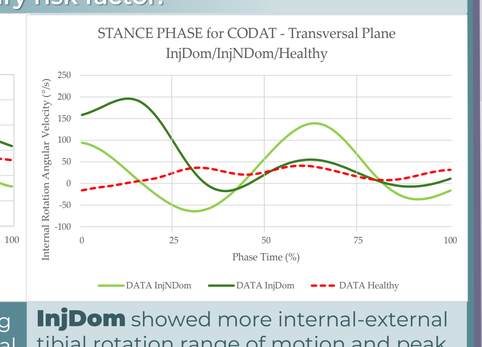
InjDom initiated the LOAD phase with the **highest speeds** in the negative or **valgus direction**.



The axial forces increasing compression on the lateral side of the knee during valgus collapse. This compression, along with the posterior slope of the lateral tibial plateau, increases internal tibial rotation.

TRANSVERSE PLANE

InjDom exhibited the **greatest internal tibial rotation** direction in the **initial LOAD phase.**



InjDom showed more internal-external tibial rotation range of motion and peak internal rotation angular velocity compared to Healthy.

These are consistent with research indicating that greater **transverse plane** motion is associated with **elevated ACL injury risk.**

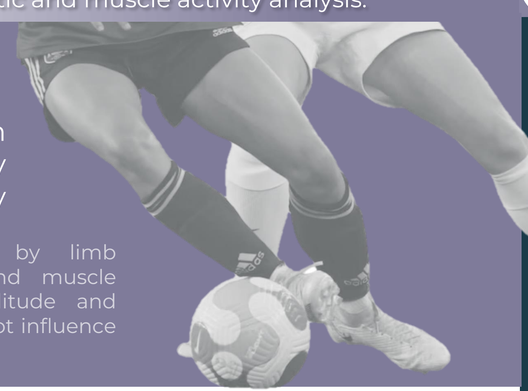
These findings are consistent with research identifying **valgus collapse** as a **key ACL injury risk factor.**

Kinematic difference observed in the initial LOAD phase is likely connected to altered muscular activity during the PREP phase. Since the limb is non-weightbearing before the LOAD phase, its kinematics are solely influenced by muscle activity explaining the importance of integrating mixed kinematic and muscle activity analysis.

CONCLUSION

1 This study identified differences in kinematics, in particular knee angular velocity, and muscle activity between players at risk of ACL injury and healthy players.

2 These differences were influenced by limb dominance condition in kinematic and muscle activity outcomes, however the amplitude and direction of the change of direction did not influence kinematics or muscle activity strategies.



DISCUSSION

MUSCLE ACTIVITY

Muscle activity analysis reveals that during the **PREP phase**, **InjDom (54%)** and **Healthy (53%)** exhibit significantly **higher average** rectified **ST muscle activity** compared to **InjNDom**.

SEMITENDINOSUS

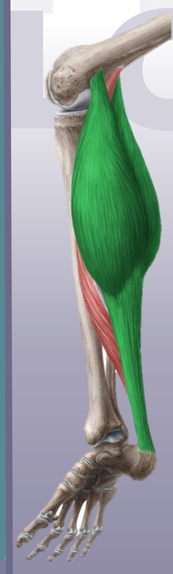
Recent research suggest that players with lower neuromuscular adaptability show increased muscle activity to stabilize sudden imbalances

InjDom higher ST muscle activity is potentially linked to the higher angular velocity observed in these players during the early LOAD phase across all planes of motion. This may result from the alignment of the angular velocity direction with the primary antagonist functions of the ST.

Consequently, the increased ST muscle activity in InjDom during the PREP phase, could impair motor control delaying activation during the LOAD phase. This delay may explain the higher angular velocity observed in flexion, in valgus and in internal rotation mechanisms closely associated with ACL injury risk as described in the literature.

PREP PHASE

LOAD PHASE



Muscle activity analysis reveals that during the **LOAD phase**, **InjDom (42%)** demonstrated significantly **higher peak** envelope **LG muscle activity** compared to **Healthy**, observed exclusively in the TURN test.

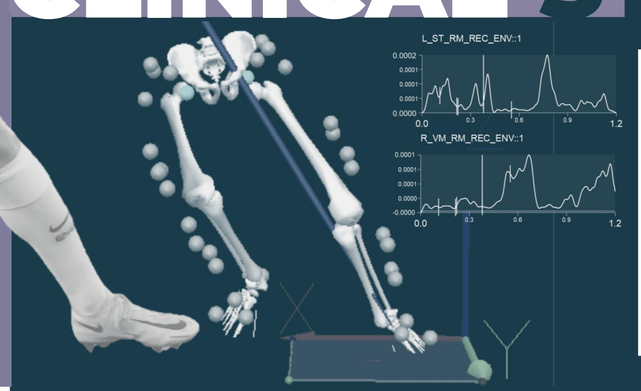
LATERAL GASTROCNEMIUS

Due to its anatomical position, the gastrocnemius enables posterior femoral translation and posterior knee compression. This interaction synergizes with the quadriceps to generate anterior tibial shear forces and reaches its peak early in the LOAD phase, increasing ACL load.

InjDom increased LG peak envelope observed in may indicate an **elevated risk of ACL injury**.

This could be attributed to **muscle compensation** related to dysfunctional hamstrings muscle activity in InjDom. This pattern may raise immediate ACL injury risk and contribute to long-term vulnerability.

CLINICAL STATEMENT



This highlights the importance of assessing kinematics alongside specific muscle activity during functional tests, replicating ACL injury mechanisms, to better determine player risk profiles and design more effective prevention programs.