

Relationship between knee anatomy, muscle morphology and activation patterns during a drop jump in female and male soccer players

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Summary

This study addresses the relationship between bony knee structure, muscular activity as well as kinematic movement patterns during a Drop Jump (DJ) in male and female healthy soccer athletes in pre-fatigued and fatigued condition, in order to gain better insights into factors influencing ACL-injury risk and their dependency on sex and fatigue. Significant sex differences were identified in lateral femoral condyle index, cross sectional areas of hamstring and quadriceps muscles and hamstring activation patterns independent of fatigue. Medial hamstring activation was dominant in female athletes, whereas males tended to lateral hamstring activation. In female athletes, steeper lateral posterior tibial slopes were among others moderately correlated with decreased medial knee displacement during DJ. Sex dependent differences and moderate relationships between muscle activation and knee anatomy exist independent of fatigue and should be considered in ACL-injury prevention treatment.

Introduction

Despite the ongoing risk of anterior cruciate ligament (ACL) injury in soccer players, with females being at higher injury risk, little is known about the effects of the knee joint's bony anatomy and its relationship to knee surrounding muscular activation during movements associated with ACL-injury mechanisms. Studies that simultaneously investigate anatomical and biomechanical measurements considering sex and fatigue are widely lacking. Anatomical characteristics such as a steeper lateral posterior tibial slope (PTS) [1, 2] or increased lateral femoral condyle index (LFCI) [3] were identified as potential ACL-injury risk factors. Additionally the specific characteristics, such as steeper lateral PTS might influence the muscular morphology and consequently the movement pattern. Therefore the aim of this study was to investigate the relationship between lateral PTS, LFCI, muscular cross sectional areas and muscular activation patterns as well as knee kinematics during a Drop Jump (DJ) in dependency of sex and fatigue.

Methods

Magnetic resonance images of the left and right limb of 15 female (21 ± 3 yrs, 167 ± 7 cm, $62,9 \pm 9.6$ kg) and 17 male (22 ± 3 yrs, 179 ± 7 cm, 74 ± 8 kg) healthy national-level soccer players were recorded to assess lateral PTS characteristics, LFCI and thigh muscle anatomical cross section areas of the quadriceps (CSA_{quad}) and hamstring muscles (CSA_{ham}). In addition, all participants performed a DJ before and after a fatigue protocol [4] during which muscle activation patterns of the quadriceps and hamstring muscles and the medial knee

displacement (MKD) [5] were recorded. Ratios between quadriceps to hamstring (QH) and lateral to medial hamstring (LM_{ham}) activation were calculated. Sex and fatigue effects on muscular and movement characteristics were assessed using a MANOVA, while the relationships between bony anatomy and thigh muscle morphology were evaluated using Persons correlation coefficients for male and female athletes independently.

Results and Discussion

Females presented a smaller LFCI ($p < 0.001$) and CSAs ($p < 0.001$) and showed significantly greater relative hamstring activation in pre-fatigued and fatigued states ($p = 0.035$) than males. Independent of fatigue medial hamstring activation was dominant during DJs in female athletes, while males tended to lateral dominant hamstring activation ($p = 0.033$). In females steeper lateral PTS slopes were moderately associated with decreased hamstring activation ($r = -0.325$), decreased lateral-to-medial hamstrings activation ratio ($r = 0.474$), increased quadriceps-to-hamstrings activation ratio ($r = 0.376$) and decreased MKD ($r = -0.390$). Male athletes demonstrated a moderate association between lateral PTS and quadriceps activity ($r = 0.386$) and between CSA_{quad} and hamstring activation ($r = -0.441$).

Conclusions

Sex-differences in thigh muscle activation during drop jump landing under pre-fatigued and fatigued conditions, as well as sex-dependent moderate associations between muscle activity and anatomy exist and should be considered in ACL-injury prevention treatment.

References

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