The effect of strengthening the muscles of the foot on common ligament injury mechanism in females participating in court sports.

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Introduction

The rapid, unexpected changes of direction of court sport often cause the relatively large explosive ground reaction force (GRF) to not act through the ankle and/or knee joint centres of the stance leg. The deviating GRF increases the risk for sustaining non-contact anterior cruciate ligament ruptures (ACL) and/or lateral ankle sprains (LAS) (B. P. Boden, Torg, Knowles, & Hewett, 2009; Fong, Chan, Mok, Yung, & Chan, 2009; Fong, Ha, Mok, Chan, & Chan, 2012; Gamada, 2014; Gould, Hooper, & Strauss, 2016; Stuelcken, Mellifont, Gorman, & Sayers, 2015). Various differentiating characteristics between the male and female athlete increases the ligament injury risk for females participating in court sports (Gould, et al., 2016; Shultz et al., 2015).

ACL and LAS injury mechanism research site foot mechanics as part of the injury mechanism, but very few intervention programs aim to change foot function directly (Gamada, 2014; Hewett et al., 2005; Shultz, et al., 2015; Willems, Witvrouw, Delbaere, De Cock, & De Clercq, 2005). Previous research suggest that ankle and knee biomechanics are influenced by barefoot and/or minimalist footwear and that the frequency and severity of lower limb injuries can be influenced by strengthening of the intrinsic and extrinsic muscles of the foot (Altman and Davis, 2012; Barry P. Boden, Sheenan, Torg, & Hewett, 2010; Nigg, Baltich, Federolf, Manz, & Nigg, 2017; Stacoff, Steger, StüSsi, & Reinschmidt, 1996).

The aim of this project is therefor to investigate the effect that footwear condition and strengthening specific muscles acting on the will have on the injury mechanism associated with ACL and lateral ankle sprain injuries.

Methods

Eighteen female court sport athletes (netball, volleyball and badminton), (age: 17.4 ±1.49 years; height: 1.68 ± 0.04m; mass: 64.53 ± 9.02kg) were randomly allocated to the training group or the control group. The training group underwent an additional 16-week progressive foot muscle-strengthening program. Foot muscle strengthening exercises was performed three times per week. The exercises chosen aimed to strengthen both the intrinsic and extrinsic muscles acting on the foot.

Counter movement jumps (CMJ) and 45° unanticipated cutting tasks were used to investigate the changes of the frontal plane ankle and knee moment arms, frontal plane ankle and knee joint angles as well as rotational velocity of the shank.

3D motion caption and GRF data was captured for the dominant leg. The data was recorded at maximum vertical GRF recorded when landing from CMJ. For the 45° unanticipated cutting tasks the data at transient and peak vertical GRF was used.

Performance parameters jump height, approach speed, stance time, acceleration through stance phase where recorded form the CMJ and during cutting tasks respectively.

Results

Performance variables

Athletes jumped 8% higher shod than when barefoot. Performing the 45°cutting task shod also resulted in 2% faster approach speed. Barefoot, the athletes had improved performance for stance time (7% reduction) and a 12% faster acceleration time during the stance phase of the 45°cutting task.

The intervention training had no effect on CMJ height. However, for 45°cutting task the training group had a smaller decrease in acceleration in both barefoot (control group decrease 59%, training group decrease 11%) and shod conditions (control group decrease 44%, training group decreased 17%) compared to the control group.

Kinematic variables

The ankle inversion angle was smaller shod compared to barefoot for both the CMJ (125%) and at the transient (22%) and peak (39%) time points of the 45°cutting task. In contrast, the knee valgus angles where smaller barefoot compared to shod for the CMJ (46%) and at the transient (93%) and peak (59%) time points of the 45°cutting task. The shank internal rotational velocity for the CMJ was 76% slower barefoot compared to the shod condition. During the cutting task the shank internal rotation was slower barefoot compared to shod at the transient (480%) and at the peak the barefoot condition was 40% faster than shod. The external ankle inversion moment arm at transient was 175% and at peak 334% larger shod compared to barefoot for the cutting tasks. The external frontal plane moment arm at transient was 861% and at peak 5% closer to the knee joint centre when performing the cutting task barefoot compared to shod.

Discussion

Performance

There is no clear recommendation with regards to footwear condition to enhance athletic performance of females during court sport activities as results where varied. The intervention training had no statically significant effect on performance variables. However, the athletes that underwent the strength training intervention had a smaller loss in acceleration in both footwear conditions possibly indicating the benefit of strengthening the muscles acting on the foot.

Kinematic outcome variables

The risk to ACL and LAS injury was reduced when the cutting task was performed barefoot. ACL injury risk was also minimised when the CMJ was performed barefoot, however the risk to LAS may be increased.

The training intervention may have further decreased the risk for ACL and LAS injury. Although, the effect of the intervention training on ACL and LAS injury mechanics was not significant. The external ankle inversion moment arm length was smaller for the training group compared to the control group in both barefoot and shod conditions.

The training group also presented with a smaller increase in the external knee frontal plane moment arm length as well as a reduction in the shank's rotational velocity in both footwear conditions.

Conclusion

ACL and LAS injury risk was reduced when CMJ and 45° cutting tasks was performed barefoot. The risk to ACL and LAS injury seems to be further reduced for the athletes who performed the exercises aimed at strengthening the muscles acting on the foot.

Prudent care should thus be taken when introducing barefoot/ minimalist shoe wear into court sport activities. Should an athlete decide to take advantage of the benefits associated with adopting barefoot/ minimalist shoe play and/or training, a gradual foot wear change complimented by strength training for the muscles acting on the foot is strongly recommended.

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