EFFECTS OF EXAGGERATED PRONATION AND SUPINATION ON LOWER EXTREMITY MECHANICS DURING A CUTTING MANEUVER

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INTRODUCTION

The mechanism of non-contact ACL injury is commonly associated with a position of knee valgus and tibial external rotation which occurs during sudden twisting or cutting. The literature is contradictory about how foot pronation relates to knee motion and ACL injury. While excessive pronation has been identified as a risk factor [1], this motion is typically coupled with tibial *internal rotation*, and it is tibial *external rotation* that is observed at the time of injury. The purpose of this study was to determine how exaggerated pronation or supination influenced lower extremity kinetics and kinematics during a side cutting maneuver.

METHODS

Ten active college-age males, with no current lower extremity impairment, volunteered to participate. Three-dimensional kinematic data were collected at 200 Hz and ground reaction force data were collected at 1000 Hz. Subjects ran 4.5-5.0 m/s, and watched for a visual cue to run straight ahead, cut 45° to the left, or stop quickly. This design was intended to elicit an unanticipated cutting response, which has been shown to differ from anticipated cutting maneuvers [2]. The right leg of all subjects was tested. Only the cutting trials were analyzed.

Subjects wore custom-made running shoes: a pair with a neutrally-posted midsole, a pronated pair with an 8° lateral rearfoot wedge, and a supinated pair with an 8° medial rearfoot wedge [3]. Five trials of each activity (run, cut, stop) were collected in each of the three shoes, for a total of 45 trials.

Three-dimensional hip, knee, and ankle joint kinematics and kinetics were calculated. Peak joint angle and moment data were extracted from the stance phase and analyzed using repeated measures ANOVA ($p<0.05$).

RESULTS AND DISCUSSION

The pronated shoe caused a significant change in ankle mechanics. Peak ankle eversion angle ($f_{2,18}=3.51$, $p=0.05$), and ankle inversion moment ($f_{2,18}=10.96$, $p<0.001$) were significantly increased in the pronated shoe. It was expected that any change that occurred at the ankle would be transferred up the kinetic chain and result in changes at the knee and hip. However, no significant changes in either knee or hip kinematics were seen. Joint angle patterns observed in this study are similar to those previously reported [4,5]. The pronated shoe did cause the knee external rotation moment to be significantly lower ($f_{2,18}=5.03$, $p=0.02$), and there was a trend that the pronated shoe also caused the knee varus moment to be lower ($p=0.10$) (Table 1). This indicates that in the pronated shoe there was less demand on the knee joint to maintain transverse plane stability.

These findings seem to contradict the theory that excessive pronation increases the stress at the knee during a cutting maneuver, and is therefore a risk factor for ACL injury. The pronated shoe with its lateral wedge seemed to provide an inclined push-off surface that re-oriented the ground reaction force vector in such a way that the stability of the knee was enhanced.

These findings may not be directly related to the mechanics of an individual with anatomical excessive pronation. These individuals would not have the benefit of the angled push off surface that existed in the pronated shoe design. The supinated shoe, however, could have approximated the effect of a posted orthotic, which did not lead to significant differences in kinematics or kinetics as compared to the neutral shoe.

CONCLUSIONS

The shoe that exaggerated pronation enhanced the transverse plane stability at the knee, and caused less rotational torque on the knee joint. Additional research is needed to identify if this pattern is consistent in females, and if anatomical pronation causes the same effect.

REFERENCES

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Table 1: Group mean (± SD) differences in ankle (A) and knee (K) mechanics (peak values) between medial (supinated), neutral, and lateral (pronated) posted shoes during a cutting maneuver. * = Significantly different from the neutral and supinated shoes ($p < 0.05$)

	A Eversion Angle (°)	A Inversion Moment (Nm)	K Int. Rot. Angle (°)	K Ext. Rot. Moment (Nm)	K Valgus Angle (°)	K Varus Moment (Nm)
Supinated shoe	-3.3 ± 5.3	21.5 ± 16.3	4.2 ± 4.3	-28.1 ± 17.1	-5.9 ± 5.4	132.2 ± 68.1
Neutral shoe	-3.8 ± 5.6	22.9 ± 17.5	3.2 ± 3.8	-30.6 ± 18.8	-6.3 ± 4.7	124.7 ± 56.6
Pronated shoe	*-5.2 ± 5.7	*25.9 ± 17.7	3.4 ± 3.3	*-20.7 ± 12.7	-6.5 ± 5.3	109.3 ± 56.8