

SHOE DESIGN AND LATERAL STABILITY IN FLOORBALL

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INTRODUCTION

Floorball (Unihockey) is one of the youngest indoor sports with a high incidence of various forms of lateral cutting movements. To improve lateral ankle stability and to decrease the risk of injury, floorball players often wear high-cut shoes and/or braces (Avramakis et al., 1999). The purpose of this study was to quantify the lateral stability of high-cut versus low-cut shoes during two typical floorball cutting movements, the forward-sideward cutting movement (FSC) and the sideward cutting movement (SC).

PREVIEW AND THEORY

Lateral cutting movements are very frequent in a number of sports activities (Stacoff et al., 1996). Typically, during such a movement, the medial side of the shoe sole touches the ground first, producing a large lever relative to the subtalar joint axis and subsequently a large supinating movement. In the attempt to reduce oversupination a number of ankle stabilization devices such as ankle braces, taping and various shoe sole designs have been tested in previous studies (Bunch et al., 1985, Laughman et al., 1980). Further improvements were reported with a reduced shoe sole thickness and anisotropic sole properties (Stacoff et al, 1996). However, little is known about the systematic influence of high-cut versus low-cut shoes on the heel inside the shoe during the execution of a typical floorball sideward cutting movements.

PROCEDURES

A two-dimensional motion analysis was performed using a Locam camera (200 fps) and Kistler force plate (1000Hz) for data capture. Twelve healthy male subjects playing floorball 6 hours a week (av. 22 yr., height 177cm ±5, bodyweight 70kg±5.7) were recorded performing the two typical floorball sideward cutting movements. The FSC movement consisted of a straight run-up of 5-7 steps onto the force platform where a lateral cutting movement of 110°-130° was executed. In the SC movement the subjects moved laterally onto the force platform then were side-cutting back in the direction of the run-up. In total, each subject performed six test movements onto the force platform in a competitive manner with two types of shoes (adidas worldteam low-cut and high-cut with identical shoe sole properties) as well as barefoot for comparison. Windows were cut out at the heel counter of the shoes to make heel movement inside the shoe visible in the frontal plane. Test variables were (a) the maximum range of supination of the Achilles tendon angle, (b) the maximum ground reaction forces in the vertical direction F_z , and the resultant force $F_R = \sqrt{F_x^2 + F_y^2}$. Supination differences were tested using a nonparametric test (Wilcoxon), force differences by using the t-test at $p < 0.05$.

RESULTS

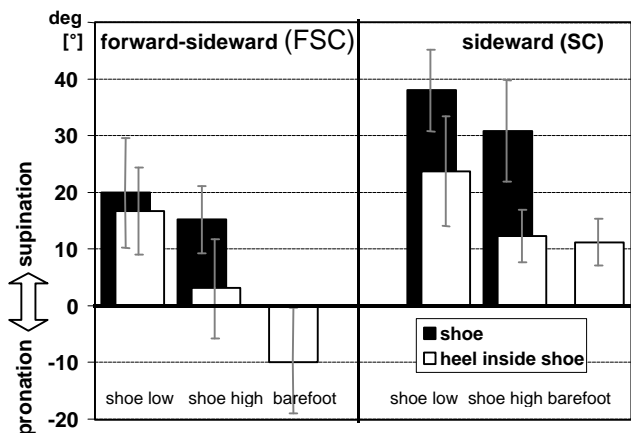


Fig. 1: Maximal range of motion of the Achilles tendon angle under different conditions

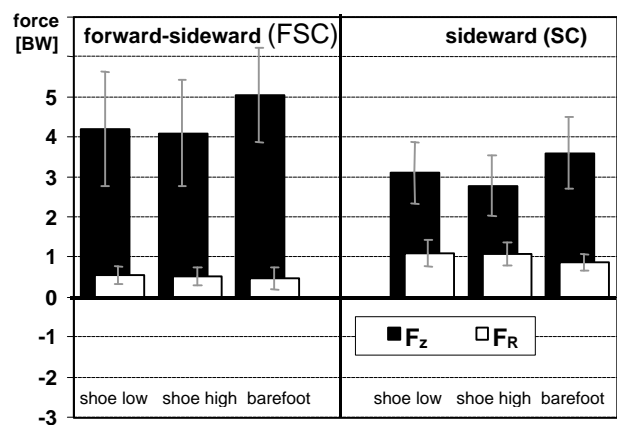


Fig. 2: Maximal vertical force F_z and maximal resultant force F_R (BW=body weight)

Achilles tendon angle

Figure 1 shows that during SC movements shoe and heel supination were significantly increased compared with FSC movements. During the FSC movement the test subjects supinated with both shoe types, but pronated when performing the test barefoot; two subjects pronated inside the high-cut shoe. Heel supination was significantly reduced by an average of 80% (from $16.8^{\circ} \pm 7.7^{\circ}$ (low-cut) to $3.0^{\circ} \pm 8.8^{\circ}$ (high-cut)). During the SC movement the test subjects supinated with both shoes as well as barefoot. Heel supination was reduced significantly by an average of 50% (from $23.7^{\circ} \pm 9.7^{\circ}$ (low-cut) to $12.3^{\circ} \pm 4.6^{\circ}$ (high-cut)) using the high-cut shoe compared to the low-cut shoe.

Forces

Figure 2 shows that during SC movement the maximum vertical forces were significantly decreased compared with FCS movements. The highest vertical forces were observed in the barefoot condition (significant to high-cut shoes). Also significant were the F_R forces of both shoes compared to barefoot. All other comparisons between test conditions were not significant.

Correlation coefficients between (a) maximum supination and bodyweight and (b) maximum supination and body height were calculated for the movement with largest supination (SC). The coefficients were (a) $r=0.75$ and (b) $r=0.88$. This indicated that maximum supination in SC movements may partially be related to bodyweight and height.

DISCUSSION

Heel supination inside the shoe can be significantly reduced when wearing high-cut shoes (compared to low-cut shoes) in floorball cutting movements. This result confirmed previous investigations of other sports activities. Thus, it may postulated that in floorball the risk of ankle injury can be reduced not only by using braces, but also by using high-cut shoes.

As expected the magnitude of supination depended on the direction of movement. It was larger in SC movements compared to FSC movements. It can be argued that in the SC movement the shoe sole (i.e. the shoe sole thickness) played an important role as an acting lever about the subtalar joint axis. However, it was not expected that all test subjects would pronate in the barefoot condition. This led to the suggestion that the subjects adapted their movement patterns not only to the type of cutting movement, but also to the shoe condition.

Furthermore, the results suggested that maximum supination may be related to bodyweight and height. This opens the possibility that the design of floorball shoes may be tuned towards individual demands.

High force values of 4-5 BW were recorded in the FSC movement which suggested that the cushioning properties of the sole should be improved in future floorball shoes. Additionally, a "whipping action" of the Achilles tendon was observed in some test subjects at the same time as the maximum vertical force occurred. This Achilles tendon whipping action has previously been observed during running by Clement et al. (1984) and was suggested to be related with Achilles tendon problems. Thus, a future floorball shoe sole design should have a combination of properties: First, a sole material which is effective in reducing vertical loads (e.g. at the Achilles tendon), and secondly, which can reduce the acting lever relative to the subtalar joint axis.

CONCLUSIONS

The two forms of lateral cutting movements showed opposite effects on supination and ground reaction forces. The consequences for future floorball shoe design can be summarized as follows:

- (a) a high-cut upper to reduce supination;
- (b) a shoe sole design with a combination of shoe sole properties: First, a sole material which is effective in reducing vertical loads and secondly, a sole construction which is effective to increase lateral stability.

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