MINIMIZING SHOE-SURFACE FRICTION AT INITIAL CONTACT: A NOVEL APPROACH TO PREVENT LATERAL ANKLE SPRAINS

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The lateral ligament complex is the most frequently injured single structure in the body. The purpose of this study was to investigate how minimizing lateral shoe-surface friction could aid in the prevention of lateral ankle sprains. Two initial studies were carried out to examine the effect of reduced lateral friction during two typical but different indoor sports movements. Ankle joint moments were analyzed using an inverse dynamics model and revealed that minimizing lateral shoe-surface friction does not affect performance and ground contact mechanics during typical indoor sports movements. These movements are in general performed with a medial initial contact. Based on these results, a future test protocol is outlined testing the preventative effect of Spraino® Slide when initial contact is carried out with an initially supinated foot position during landing and cutting situations.

KEY WORDS: injury prevention; injury mechanism; tribology; Spraino; footwear

INTRODUCTION: Ankle injuries are extremely common with several studies describing the ankle joint as the most common site of injury (Verhagen & Bay, 2010; Wright, Neptune, van den Bogert & Nigg, 2000; Garrick, 1977). In a review study, the ankle joint was reported as the most injured body part in 24 out of 70 investigated sports. In all sports combined it was reported as the second-most injured body part (Fong, Hong, Chan, Yung & Chan, 2007). Ligamentous sprains are the most common type of ankle injury, of which the lateral ligament complex is the most frequently injured single structure in the body making up approximately 75% of all ankle injuries (Fong et al., 2007; Garrick, 1977). Ankle sprain injuries account for up to one sixth of all injury lay-off from sports (Wright et al., 2000) with up to 50% suffering from chronic ankle instability following an ankle sprain injury (Verhagen & Bay, 2010). With an annually estimated cost of €187,200,000 in the Netherlands alone (Hupperets et al., 2010) it is an important issue to address.

Ankle sprain prevention strategies have been recommended in indoor sports such as volleyball, handball and basketball etc. due to high injury risk and participation rate (Fong et al., 2007). Current prevention strategies include taping, bracing and neuromuscular training. These strategies are linked with up to 50% reduction in ankle sprain recurrence (Verhagen & Bay, 2010). These measures are thought to aid in ankle sprain prevention by preventing an inappropriate foot position prior to touchdown (TD). Such an inappropriate foot position is believed to have a great influence on the risk of sustaining a lateral ankle sprain. A supinated and/or plantar flexed foot at TD is believed to increase the ground reaction force moment arm about the subtalar joint. (Wright et al., 2000)

Spraino® Slide is an adhesive polytetrafluoroethylene (PTFE) patch that, in contrast to current prevention strategies, does not seek to alter foot positioning prior to contact (Wright et al., 2000; Verhagen & Bay, 2010). The patch is attached along the lateral forefoot on the edge of the shoe. It is intended to reduce shoe-surface friction when initial contact is carried out with the foot placed in an inappropriate position. In this case a sliding movement will occur that will act as a prophylactic measure by correcting the foot position and reduce the moment arm about the subtalar joint before full load is applied (Figure 1).

The purpose of this study was to investigate how the use of Spraino® Slide affects typical indoor sports movements.

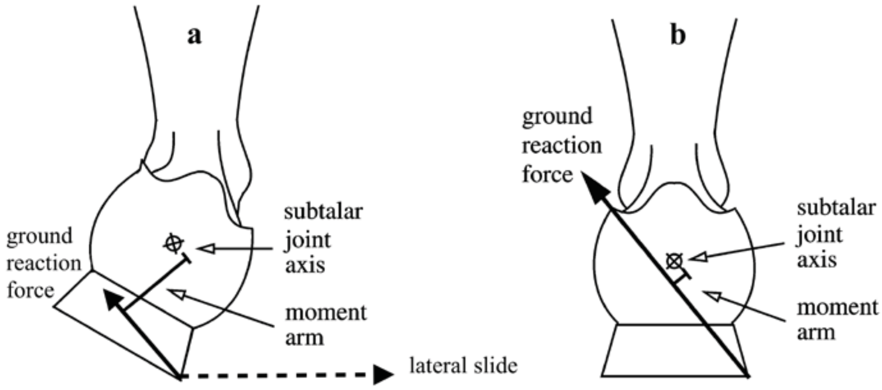

Figure 1: The intended effect of Spraino® Slide: The foot will slide laterally when initial contact takes place in a supinated position. Figure adapted from Wright et al. (2000).

METHODS: Nine healthy female elite handball players (age: 21 ± 2.4 years; height: 176.6 ± 9.84 cm; mass: 73.8 ± 9.7 kg) participated in the first study where a submaximal 90° lateral side-cut movement while receiving a pass was performed. Three different intervention conditions were tested against a control condition. In the first intervention condition a Spraino® Slide was attached along the lateral edge of the shoe with a 10 mm margin. In the second intervention condition a 3 mm margin was applied. In the third intervention condition the Spraino® Slide had a sinusoidal-shaped design underneath the sole. For the control condition, the Spraino® Slide did not cover the edge of the shoe and was attached on the side of the shoe for blinding purposes only.

Eight healthy female athletes (age: 21.3 ± 0.7 years, height: 172.0 ± 3.6 cm, mass: 66.4 ± 8.5 kg) participated in the second study where a 180° change of direction maneuver was performed at maximal effort. In this second study, only the 10 mm margin below the sole was tested against the control condition. The eight subjects were randomized to start with either the control or intervention condition and completed eight trials in both conditions.

Both studies were approved by the regional ethics committee and all subjects provided written consent. Both studies were designed as a single-blinded randomized cross-over study in which the subjects wore a pair of commercially available Adidas Stabil Boost™ handball shoes (Adidas AG, Herzogenaurach, Germany).
Ground reaction forces (GRF) were collected at 2000 Hz using a force plate (AMTI OR6-7-1000, MA, USA). Kinematic data were collected at a sample rate of 500 Hz using eight infrared Qualisys Oqus 300+ series cameras and processed in Qualisys Track Manager (Qualisys AB, Gothenburg, Sweden). Kinematic data were low-pass filtered using a 4th order Butterworth filter with cut-off frequencies of 100 and 14 Hz, respectively. Inverse dynamics simulations were carried out using Visual 3D (C-Motion Inc., Germantown, Maryland, USA) and ankle joint kinetics were analyzed between touch down and toe-off. Statistical analyses were conducted using IBM SPSS Statistics (PASW statistics, version 24, IBM Corporation, New York, USA). In the first study, a repeated measures ANOVA was applied to test for statistical differences in joint inversion moment and contact time. A paired sample t-test was applied in the second study for the same parameters.

RESULTS: A repeated measure ANOVA showed no significant difference between the control condition and the three intervention conditions in any of the investigated parameters. The use of Spraino® Slide did not affect contact time, ground reaction forces or ankle joint kinetics between touch down and toe-off of the stance phase of a submaximal 90° lateral side-cut movement while receiving a pass. Visual inspection of the data revealed that touchdown in all cases was performed with initial contact at the medial side of the shoe.

These unaffected movements led to the second study in which a more demanding maximum effort 180° change of direction maneuver was performed. However, no difference appeared in ankle inversion moment during the stance phase (Figure 2). A paired sample t-test showed no significant difference in contact time, peak inversion moment and inversion moment at TD between the control and intervention condition, despite the exaggerated 10 mm margin of patch covering the sole. In all cases touchdown was again performed with initial contact being made with the medial side of the foot. Kinematic analyses showed that the subjects changed direction with an in average medial foot-ground inclination angle at touch down of 17.4° ± 8.2 with Spraino and 17.5° ± 10.0 without Spraino.

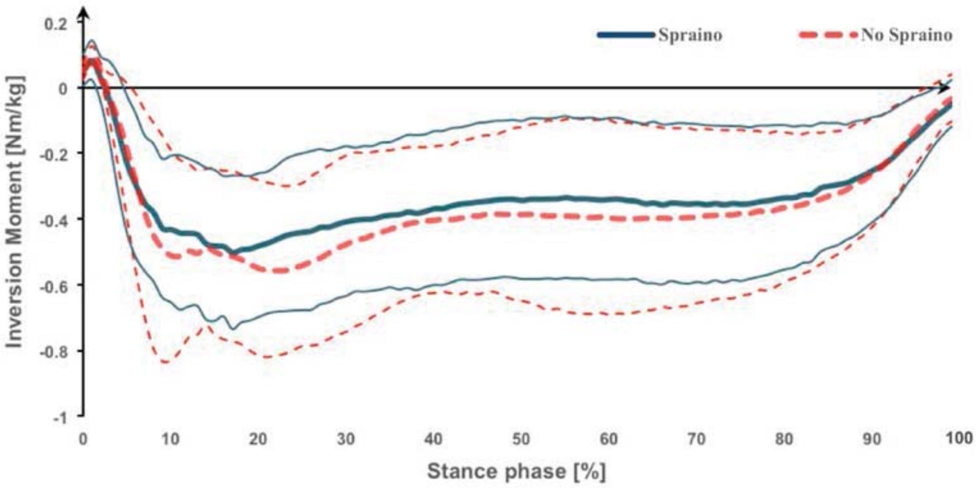

Figure 2: Mean Inversion Moment ± SD in Nm/kg during the stance phase in a 180° change of direction movement.

DISCUSSION: The unaffected movements in both experiments indicate that the use of Spraino® Slide does not affect performance or safety during typical indoor sports movements. This is highlighted by the fact that none of subjects in the two studies changed direction with initial contact on the lateral edge of the shoe. The fact that no subjects landed with an inappropriate foot position could be due to the laboratory setting in which the experiment was conducted. This could make the subjects focus on performing the movements in the best possible way. In addition, none of the subjects tested had previously experienced ankle sprain injuries.

These two studies are however restricted by the fact that they can only explain what happens when a change of direction is carried out in a proper way and not in a potential injury situation.

An upcoming study by the presenting author is set to investigate the preventative effect of Spraino® Slide when TD is carried out with an initially supinated foot position during different landing and cutting situations. This study will have a mechanical approach in which the subjects will be fixed above a moveable force platform. Simulated landing situations will be completed with controlled different initial foot positions before the force platform is moved towards the foot. This study will investigate the preventative effect of a reduced lateral shoe-surface friction and provide information on how the ankle joint is loaded in regards to initial foot position. Furthermore, knowledge will be generated as to what can be regarded as an inappropriate foot position.

CONCLUSION: Minimizing lateral shoe-surface friction does not affect performance and ground contact mechanics during the investigated change of direction movements. Attaching Spraino® Slide to the lateral edge of the shoe does not affect performance during submaximal 90° lateral side-cut movement while receiving a pass and full-effort 180° change of direction maneuvers. These results are valid in the extent where the maneuver is performed with initial contact on the medial side of the foot.
The presented upcoming study will investigate the preventative effect of Spraino® Slide when touchdown is carried out in an inappropriate, initially supinated position.

REFERENCES:

Fong, D. T. P., Hong, Y., Chan, L. K., Yung, P. S. H., & Chan, K. M. (2007). A systematic review on ankle injury and ankle sprain in sports. *Sports medicine*, 37(1), 73-94.

Garrick, J. G. (1977). The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *The American journal of sports medicine*, 5(6), 241-242.

Hupperets, M. D., Verhagen, E. A., Heymans, M. W., Bosmans, J. E., van Tulder, M. W., & Van Mechelen, W. (2010). Potential savings of a program to prevent ankle sprain recurrence: economic evaluation of a randomized controlled trial. *The American journal of sports medicine*, 38(11), 2194-2200.

Verhagen, E. A. L. M., & Bay, K. (2010). Optimising ankle sprain prevention: a critical review and practical appraisal of the literature. *British journal of sports medicine*, 44(15), 1082-1088.

Wright, I. C., Neptune, R. R., van den Bogert, A. J., & Nigg, B. M. (2000). The influence of foot positioning on ankle sprains. *Journal of biomechanics*, 33(5), 513-519.

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