Overview

Ankle injuries and primarily ankle sprain is the most common among lower limb injuries. Studies reported high number of ankle injuries occurs in the most common team sports like football, handball, basketball and volleyball (6). Approximately 80% of ankle injuries are ligamentous sprains and the remaining 20% are ligament ruptures (4). A former study analysed the different injuries in 8 team sports during the 2004 Olympic Games in Athens. They recorded 48 ankle injuries, which in details were 1 dislocation, 8 contusion and 38 ligamentous sprains or ruptures (11). This type of injury aside of the mechanical and structural alterations can induce changes in the function of the neuromuscular system and influence the motion. Studies reported that depending on the requisition of each team sport, from 9 to 40% of the team players suffering of instability for a long term after ankle sprain (4, 6). Steib et. al. found that the athletes who had previous ankle sprain had greater fatigue-induced alterations in movements than athletes without injuries. These alterations may cause increased risk of the injury occurs again (16). Brown et. al. (YEAR) separated movement alterations by mechanical and functional instability in the ankle and found that there are difference among the movement patterns of the two type of instability. The two separated movement alterations helped to avoid ankle sprains during activities but increased the risk of ankle degeneration (3). The mechanical aspect of the lateral ankle sprain is, when the vertical axis of the centre of the body mass placed outside of the vertical axis of the ankle joint, excessive inversion happen on the ankle which often paired with forced plantar flexion. There are different opinions about the role of the plantar flexion during the injury among the studies, but Gehring et. al. investigated 3D kinematics and kinetics and muscle activity of the lower limb in relation with ankle sprain and found the forced plantar flexion was always appeared during the ankle sprain (9). In mechanics the ankle depicted as a hinge joint, but its structure is more complex than that. The ligament structure of the ankle composed by three major ligaments which ensure the lateral stability of the ankle. These three ligaments, commonly called the lateral complex, are the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL) and posterior talofibular ligament (PTFL).

As studies suggested the ATFL is more prone to injure among the ligaments of the lateral complex. In $\frac{2}{3}$ of the total number of injuries ATFL wounded, while CFL contributes less than one tenth of all ankle injuries. These injuries are called acute ankle instability. The symptoms of the injury are acute pain and pain on palpation, swellings and inability to hold weight (14). Lindner et. al. calculated the peak force of these three ligaments via inverse dynamics. They found that the peak force measured on ATFL was 97
N, on the PTFL was 150 N while on the CFL was 180 N, which describes why the ATFL the most commonly injured ligament. They measured the peak force of ATFL and PTFL at the last moment of the lift off and during landing at the first contact on the floor. The forces were in order, on ATFL 58-68 N and 61-70 N and on PTFL 70 N and 118 N (13). Kristianslund et. al. published a study about an accidental ankle sprain during a sidestep laboratory test after two successful trial. After the data comparison they attempted to describe the kinematics and kinetics during the injury. The trials were segmented to three phases. From the beginning of phase 3, the peak the inversion moment increased suddenly and reached the peak value with an accompanied rotational moment was measured as well which reached its peak value (64 Nm). While the control trials shown not more than 6° of joint angular deflection it was 16° during the injury progress. The inversion velocity was not higher than 221°/s in the control trials but it was 558°/s during the injury (12). Chu et. al. (YEAR) investigated ankle inversion velocities and measured same values as above research group while determined the threshold of ankle inversion velocity of an ankle sprain is 300°/s (4).

Many research groups tried to find a method or develop a device to prevent ankle injuries. Dizon et. al. compared the efficiency of the ankle tape, brace and orthosis. None of these solutions provided significantly better effect than other but all of them decreased the likelihood of ankle sprain by 69-71% with reducing the range of ankle motion by 48-84% of previously injured athletes (7). Raymond et. al. investigated the proprioception of previously injured athletes with and without bracing and taping and they did not find significant difference in 2/3 of the results in comparison of device and the control proprioception tests (10). Verhagen et. al. and Thacker et. al. compared the results of 24 and 113 relevant studies about well-tried ankle sprain preventive methods and found that in the general population these methods have strong preventive effects on previously injured subjects and suggested that the combination of the methods has the best possible result in ankle sprain prevention (17, 18). There were research studies between altered shoe designs but none of these studies found significant difference between different shoe designs even though one of them most likely were sponsored by a well-known sports equipment company (5, 15). Attia et. al. developed a wearable device which connected to a mobile phone via Bluetooth, recording data and prevents repetitive ankle sprain by electric stimulation of muscles which reacts with dorsiflexion to the electric signals. The device recognizes the dangerous situations and send signals 7 ms after recognition (2). Fong had a similar idea while he integrated the sensors into an intelligent sport shoe (8). To the knowledge of the authors there no study about the Ankle Roll Guard (figure 2) so far, but fundamentally this has the biggest similarity to the subject of this study in the idea of prevention (19).
The purpose of this study was to test a new Danish invention to prevent ankle sprain called Spraino. Spraino is an adhesive plaster to the lateral side of the shoe including a thin line on the ground-engaging surface. The surface of the adhesive plaster coated with a thin teflon layer which ensure the sliding effect when the ankle inversion become too high. The investigation focused on the ideal position of the adhesive plaster on the shoe side and outsole and the effect on movements during the test subjects executed sidecut movements. The group chosen by the authors were female handball players. The reason why this group was in focus because as Dallinga et. al. shown in the indoor and court sports more ankle sprain occurred among female players than men regarding to other studies (6). Handball was chosen because as Junge et. al. shown in the 2004 Olympic Games, the total number of ankle injuries among the 8 team sports were 49, and only in handball were 12 which means ~25% of the injuries occurred in handball which was the highest proportion among team sports (11).
Setup

The Spraino

Spraino was developed by Grønlykke Medical for the purpose to prolong the career of athletes with injuries and the company stakeholders obligate to offer 10% of the profit to research and charity. The developers would like to change the attitude to the injuries which in practice means it should not have to brake a sport career. The first step of this change is Spraino against the ankle injuries. The main developer, a medical doctor, has had many ankle twists and he started to think about the factors of these injuries. He found out the friction between the lateral edge of the shoe and the floor is the clue of this issue. He made a prototype which decreased the friction and the tests convinced him, because he avoided the injuries during the mechanism how the prototype worked. In practice that meant the user's shoe slid on the floor and it fell down which didn't cause further serious injuries.

The Spraino is an adhesive plaster. After the production and tests of multiple prototypes, the best result provided by the PTFE (polytetrafluoroethylene), or better known Teflon layer on the adhesive plaster. The PTFE layer is fixed with an adhesive to the surface of the plaster. The PTFE is tensile which in practice means it is more withstand against abrasive forces, more wear resistant and durable. During the development the initial simple shape which was chosen for the reason to produce easier had to change because the subsequent tests proved the modified sinusoidal shape can withstand longer against the forces during use (figure 4).

figure 4 Original version left, new version right
The shoes

The shoe supplier of the study was Adidas AG. The company has sources to develop sports equipment to top athletes and top requirements aside of commercial products. The shoes were used during the investigation is a model of Adidas Specialty Sports Collection. The shoe called Adidas Stabil Boost 1.0 W (figure 3) directly designed for professional women handball players.

![Adidas Stabil Boost 1.0 from right side, left side and from sole direction](image)

In the midsole of this handball shoe there is a special material developed by Adidas called Boost, which provides fast and comfortable movement during sudden direction changes and has good damping ability enables to avoid joint injuries. The boost built up by high number of thermoplastic polyurethane capsules (TPU). During the production the TPU capsules are heated up, formed and the result is a one-piece midsole which not contains the previously used multiple number and type foams. This material ensures higher energy return through the larger bounce-like effect during longer time-span in comparison to the previously applied midsoles. In action this new midsole construction absorbs the impact energy and the TPU capsules exert it back.

The outsole of the shoe is a high durability rubber called AdiWear which has outstanding abrasion resistance and flexible, while the shoe is still allow pivoting and sliding.

The AdiTuff material can be found inside in the region of the forefoot and toes. This material is resistant against abrasion and impacts of the forefoot during the activities, therefore the shoe can be more wear resistant and helps avoid nail injuries and bruises on foot.

The torsion system developed in 1988. This is a TPU bridge support in the midfoot region which enables the for- and rear-foot to move independently. The Torsion system maintains its shape and the foot avoids the strain effect during the movement. This enables to control the heel-to-toe transition smoothly and provide protection to the foot.

Under the forefoot and rear-foot there is a material called Sprintplate. Sprintplate similar to the Boost and together the two materials give extra energy blast during high jumps and stability during landing. In addition, Sprintplate ensures a non-slip lining for the foot.
The upper synthetic material of the shoe is called Air-Mesh. This is a breathable, high durability upper material reinforced in the regions where the material wearing the most during sports (22, 23, 25, 26, 27, 31).

**The floor**

During the study a special Taraflex Sport M Comfort Sport floor were deployed to the floor which was developed for indoor Sports produced by Gerflor, which is one of the largest manufacturers of resilient commercial flooring in the world. Taraflex is the leading brand in the field of indoor sports floor. It was used in many world indoor meeting and Olympic Games inclusive Rio de Janerio Olympic Games 2016 handball, basketball and volleyball courts.

![Figure 5: the layers of the Taraflex floor](image)

*Figure 5: the layers of the Taraflex floor*

Figure 5 shows the layout of Taraflex floors (28). The aim of the structure is that the glued subfloors has to provide a flat, smooth, safety and silent surface for the athletes. All of these materials are foams with different features and nature. The fantasy names of the layers ordered below, but the technological details are confidential.
1. Triple Action
2. ProtecsolD-Max / D-Max+
3. CXP HD
4. Sanosol

Taraflex Sport M Comfort Sport is a point-elastic floor which means because of the uniformity of the construction, a point-elastic floor will behave almost identically to impact forces across all locations of the entire floor. Furthermore, a point-elastic floor has a higher stiffness and lower elasticity compared to an area-elastic floor. In practice this means that a point-elastic floor will have less energy absorption and less vertical deformation when an impact occurs. When looking at the energy dispersion of an impact, the area of deformation is small and the energy is dispersed locally around the impact as shown in figure 6 (30).

![Point-Elastic System](image)

*figure 6: behaviour of point-elastic floors*

In the present study the authors used a 7.5 m² area Taraflex floor with 5 mm thickness, inside the calibrated area of Qualisys Track Manager system. During the deployment process the authors maximally considered the recommendations of Gerflor.
The recommended deployment conditions are: the minimum indoor and floor temperature must be above 10°C, the temperature of adhesives must be between +10°C to +30°C. During the deployment the indoor temperature must be +10°C which was veridical to the lab conditions. Acrylic Henkel Kontaklim glue was used to the bottom face of the floor and the 5cm wide double sided adhesive tape were applied, following the edges of the floor. During the gluing process the recommendations of the glue producers were considered. The tack time obeyed and observed during the process.

**Marker placement**

The placement of the markers based on previous study performed by Andersen et. al. (1). Andersen’s placement method complemented with four additional markers to the left and right ankle and knee medial positions. In total 35 passive reflective markers were placed on each subject’s body. Figure 7 shows the placement of the markers on the body and the upper and lower extremities of the subjects.

*Figure 7 shows the sketch of the placement of markers on a subject*
In order to use the handball shoes differently to Andersen’s method the authors fixed 5 retro-reflective markers to each shoe rather than the feet. Figure 8 shows the placement of the markers on the shoes. In table 1 the name of the markers, their positions and labels are further described.

![Figure 8: Marker placement on Adidas Stabil 1.0 shoes](image)

**Table 1 shows the marker names, and their respective positions**

<table>
<thead>
<tr>
<th>Position of Marker</th>
<th>Anatomical Position of Marker</th>
<th>Marker Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>4 markers on a headband</td>
<td>RHead, RBHead, LHead, LBHead</td>
</tr>
<tr>
<td>Left Shoulder</td>
<td>Left Acromion</td>
<td>LAc r</td>
</tr>
<tr>
<td>Left Upper Arm</td>
<td>Left Triceps Branchii</td>
<td>LTric</td>
</tr>
<tr>
<td>Left Elbow Medial</td>
<td>Left Olecranon Fossa Medial Epicondyle</td>
<td>LMedEp</td>
</tr>
<tr>
<td>Left Elbow Lateral</td>
<td>Left Trochlea Lateral Epicondyle</td>
<td>LLatEp</td>
</tr>
<tr>
<td>Left Wrist Medial</td>
<td>Left Styloid Process Radialis</td>
<td>LMedWr</td>
</tr>
<tr>
<td>Left Wrist Lateral</td>
<td>Left Styloid Process Ulnaris</td>
<td>LLatWr</td>
</tr>
<tr>
<td>Left Anterior Pelvic Bone</td>
<td>Left Anterior Superior iliac spine</td>
<td>LASIS</td>
</tr>
<tr>
<td>Left Posterior Pelvic Bone</td>
<td>Left Posterior Superior iliac spine</td>
<td>LPSIS</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Left Thigh</td>
<td>Left Quadriceps</td>
<td>LThigh</td>
</tr>
<tr>
<td>Left Knee Medial</td>
<td>Left Medial Epicondyle</td>
<td>LMedKnee</td>
</tr>
<tr>
<td>Left Knee Lateral</td>
<td>Left Lateral Epicondyle</td>
<td>LLatKnee</td>
</tr>
<tr>
<td>Left Tibia</td>
<td>Left Tibia</td>
<td>LShin</td>
</tr>
<tr>
<td><strong>Left Ankle Medial</strong></td>
<td><strong>Left Medial Malleolus (tibia)</strong></td>
<td>LMedMal</td>
</tr>
<tr>
<td>Left Ankle Lateral</td>
<td>Left Lateral Malleolus (fibula)</td>
<td>LLatMal</td>
</tr>
<tr>
<td>Left Heel 1</td>
<td>Left Calcaneus (shoe)</td>
<td>LCalc</td>
</tr>
<tr>
<td><strong>Left Heel 2</strong></td>
<td><strong>Left Anterior Process of Calcaneus (shoe)</strong></td>
<td>LLatCalc</td>
</tr>
<tr>
<td>Left Little Toe</td>
<td>Left Metatarsal 1 (shoe)</td>
<td>LMet1</td>
</tr>
<tr>
<td>Left Big Toe</td>
<td>Left Metatarsal 5 (shoe)</td>
<td>LMet5</td>
</tr>
<tr>
<td>Left Foot</td>
<td>Left Upper Metatarsal 3 (shoe)</td>
<td>LToe</td>
</tr>
<tr>
<td>Right Shoulder</td>
<td>Right Acromion</td>
<td>RAcro</td>
</tr>
<tr>
<td>Right Upper Arm</td>
<td>Right Triceps Branchii</td>
<td>RTric</td>
</tr>
<tr>
<td>Right Elbow Medial</td>
<td>Right Olecranon Fossa Medial Epicondyle</td>
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</tr>
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<td>Right Styloid Process Ulnaris</td>
<td>RLatWr</td>
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<td>Right Anterior Superior iliac spine</td>
<td>RASIS</td>
</tr>
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<td><strong>Right Posterior Superior iliac spine</strong></td>
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<td>Right Quadriceps</td>
<td>RThigh</td>
</tr>
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<td>Right Medial Epicondyle</td>
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</tr>
<tr>
<td>Right Knee Lateral</td>
<td>Right Lateral Epicondyle</td>
<td>RLatKnee</td>
</tr>
<tr>
<td>Right Tibia</td>
<td>Right Tibia</td>
<td>RShin</td>
</tr>
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<td><strong>Right Ankle Medial</strong></td>
<td><strong>Right Medial Malleolus (tibia)</strong></td>
<td>RMedMal</td>
</tr>
<tr>
<td>Right Ankle Lateral</td>
<td>Right Lateral Malleolus (fibula)</td>
<td>RLatMal</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Right Heel</td>
<td>Right Calcaneus (shoe)</td>
<td>RCalc</td>
</tr>
<tr>
<td>Right Heel</td>
<td>Right Anterior Process of Calcaneus (shoe)</td>
<td>RLatCalc</td>
</tr>
<tr>
<td>Right Little Toe</td>
<td>Right Metatarsal 1 (shoe)</td>
<td>RMet1</td>
</tr>
<tr>
<td>Right Big Toe</td>
<td>Right Metatarsal 5 (shoe)</td>
<td>RMet5</td>
</tr>
<tr>
<td>Right Foot</td>
<td>Right Upper Metatarsal 3 (shoe)</td>
<td>RToe</td>
</tr>
<tr>
<td>Cervical Vertebrae, C7</td>
<td>Cervical Vertebrae, C7</td>
<td>C7</td>
</tr>
<tr>
<td>Thoracal Vertebrae, Th12</td>
<td>Thoracal Vertebrae, Th12</td>
<td>Th12</td>
</tr>
<tr>
<td>Clavicle</td>
<td>Clavicular Articulation</td>
<td>UpEst</td>
</tr>
</tbody>
</table>

**Test protocol:**

1. The subject executes an individual handball specific warm-up in a shoe equipped with Spraino

2. The subject stands behind the self-chosen start point in shoe 1 on her feet waiting for the start signal

3. The operator sets up the system

4. Start signal: the system starts recording

5. The subject starts acceleration until obtains a consistent and sub-maximal velocity

6. The subject reaches the force plates

7. The subject jumps to the force plates and executes a sidecut using their dominant leg and lands in the designated landing zone (±22.5° in respect to the longitudinal axis of the force plates)

8. The operator sets off the system

9. Repeat points 2-8 until 3 successful trials

10. Repeat points 2-9 in shoe 2, shoe 3 and shoe 4
Force plate

During this study the authors used two strain gage technology AMTI force plates type OR-5 and OR-6. These force plates designed to measure forces and moments which the subject during its movement applied to the top surface of the device. The regular fields of using force plates are research and clinical tests or studies to develop and improve movement performance.

![AMTI OR force plate](image)

Figure 9: AMTI OR force plate

Figure 9 shows the three force and the three moment components which the force platform measures during a measurement session. The force components called Fx, Fy, and Fz are act along the axes of an orthogonal x, y, z-coordinate system. In figure 9 the forces point to positive direction along the x, y, z axes of the coordinate system following the right hand rule. In this case Fx and Fy are the horizontal or in some cases called called shear force components, and Fz is the vertical force component. The moment components called Mx, My and Mz are rotations around the corresponding x, y and z axes following the right hand rule as well. Positive moments following clockwise rotation, negative moments following counter-clockwise rotation.

The used force plate system (figure 10) made up by two AMTI OR series force plates (OR-6-5-2000 and OR-6-7-1000) with a sampling rate of 2000 Hz filtered in 1050 Hz, an amplifier, a computer with installed Qualisys Track Manager v 2.9 software and interconnecting cables. AMTI OR series good for sports investigations its relatively large surface, high capacity (9000-17000 N) to cope with large impulse forces and able to use for high frequency measurements.

![The force plate system](image)

Figure 10: The force plate system
AMTI OR force plate uses strain gage technology, which is recently the most accurate and flexible force measurement solution. On the surface of the force plate found thin-wall cylindrical elements. These elements connected to strain gauges. When a subject applies forces and moments to the surface that transfer sheer forces to the thin walls of the cylinders. These forces induce electrical resistance change in the strain gauges which change the constant voltage which excited them. These voltage changes are proportional to the forces applied to the surface.

During the tests of this study the signal excitation voltage for the strain gauges provided by a signal conditioner, which later amplified the signal returned from the force plate and provided output for the computer and processed by the Qualisys Track Manager system. The used cables were 100% double-shielded and used twisted pair conductors, which provided the highest signal sensing together with the lowest possible noise. The force plates were mounted into the prepared holes of the lab floor with screw bonding, and merged to the floor level perfectly provided a flat and rigid surface for the tests (24).

Qualisys Track Manager

Qualisys Track Manager (QTM) is a software which collects data from a motion capture system. The measurement data of this study recorded by the QTM via external devices. Two AMTI OR-5 and OR-6 force plates, two amplifiers for both force plates, 8 Oqus 1 cameras and a computer with installed QTM software. The system integrated these devices into one. This system allows measuring indoor or outdoor, in-air or underwater circumstances as well.

![Figure 11: Model in Qualisys Track Manager with markers on user interface](image)

QTM system able to compute 3D and 6 DOF data from 2D marker data with minimal latency during real-time or post-processing recording of data. The number of cameras depends on the used area size and design of the lab and the system scaled to this number. The system enables to use different type of
cameras at the same set. The QTM identify the markers automatically which makes the model definition quick and the data immediately appears on the interface (figure 11). QTM supports all the major EMG and force plate systems on the market and all type of cameras and additionally enables to export data to MatLab, LabView, C3D and Excel files. The system able to handle and process high-speed video data as well.

During this study the authors used 8 Oqus 1 infrared cameras to record the movement of the subjects in a 100 Hz sampling rate. This motion capture camera enables recording in both indoor and outdoor circumstances. The Oqus 1 (figure 12) cameras ensures low latency during motion capture and able to track active and passive markers as well. To track each marker at least three cameras have to track it at the same time for the best result, but often two cameras can be able to provide reliable data via QTM calculation from 2D data to 3D (xyz) positions.

![Oqus 1 infracamera](image)

**figure 12: Oqus 1 infracamera**

The Oqus cameras are able to track hundreds of markers at a time and provide accurate and quick calculations of marker positions. The cameras resolution can be changed from low to high resolution (1,3-12 megapixels) and high speed motion capture is among its features.

To use the QTM system for motion capture, it has to be calibrate to the local circumstances with the QTM Calibration Kit. The kit made up about wand, a foldable L-frame and an aluminium carry case (figure 13). The length of the wand is 600 mm and there are two spherical markers for the maximum calibration accuracy.

![QTM calibration kit](image)

**figure 13: QTM calibration kit**
The calibration process for 3D and 6DOF measurement called dynamic calibration method. A wand is simply moved around in the volume while a stationary reference object in the volume defines the coordinate system for the motion capture. All settings for the calibration are controlled by QTM and the result of the calibration is visualized in a quick and intuitive way. The calibration is done within 15-30 seconds.

Before the measurement process the calibrator person placed the foldable L-frame to the force plates as a stationary reference object and after walked around the volume of the area which designated to the motion capture process while he was rotating the wand in its hands. The L-frame as the stationary reference object defined the coordinate system of the area. The system automatically tracked and identified the markers on the devices and built up an area about cubes (figure 14). The minimum value of cubes and the quality of the area was determined by the recommendation manual and if the calibrated area did not reached this values the calibration process was repeated (29).

![Figure 14: Calibration area in QTM](image)

**C Motion Visual 3D Professional**

In the present study the data obtained by the Qualisys system was exported into C3D files. These files used by the Visual 3D software to compute the desired values. The first step of the analysis process was to create a master 6 DOF model using a standing trial and define the segments of the model. This master model was associated with the explored data obtained by the Qualisys and new models were built by the anthropometric characteristics of all the subjects of the trials, using anatomical and tracking markers. In order to perform any signal and event processing a command processing pipeline needed to be create. After filtering the singal of the markers, the inverse dynamics calculation was performed.
This pipeline made up about a series of commands which requested by the user and run sequentially. The pipeline automated the processing steps make the repeated and multiple task easier. In the present study the pipeline managed the computations of the desired values (ankle forces, moments, angles and contact time, etc.) and generated a report of the results.

C Motion Visual 3D is an analysis tool for biomechanics investigations. The software processes the movement and force plate data of the used motion capture system. It operates in the Microsoft Windows platform and can be able to process the data by almost all kind of 3D motion capture system. After processing the data from C3D files, the user can be able to get kinematic and kinetic calculations because the software provides optimization methods using the latest mathematical techniques, biomechanical modelling, filtering, signal processing, inverse dynamics and many more functions (20).

![figure 15: full body model in Visual 3D](image)
EFFICACY OF SLIP PATCHES ON FOOTCONTACT MECHANICS DURING A HANDBALL MOVEMENT – A PILOT STUDY

INTRODUCTION
Ankle injuries are among the most common sports injuries. A study of the 2004 Olympic Games in Athens revealed that a total of 49 ankle injuries occurred across indoor team sports whereas the largest ankle injury rate was seen in team-handball [1]. A potentially applicable approach to reduce the likelihood of injury is to reduce the friction between the foot and the surface when the foot is exposed to extreme inversion positions. Spraino patches provide a low friction tape attached to the lateral edge of the outsole which is claimed that it can reduce chance for injury.

The purpose of the current study was to investigate the effects of Spraino patches on foot surface interaction during a handball specific cutting task.

METHODS
Fourteen female elite handball players participated in the study, with pilot data from six participants being presented in this abstract. Four patch conditions were tested when applied to the outsole of a commercially available handball shoe (Adidas stabil boost) during a 90°-cutting manoeuvre while receiving a pass. Each subject carried out five trials for each patch condition (1 mm wide and 3 mm wide and straight; with a zigzag contour and with no patch (control)).

Ground reaction forces (GRF) were collected by two force plates (AMTI OR6, USA) at 1000 Hz. Kinematic data were collected from 26 retroreflective markers placed on anatomical landmarks of the lower extremities and shoes with an 8-camera motion capture system (Qualisys AB, Gothenburg, Sweden) at a sampling rate of 500 Hz. Data were low-pass filtered with a 4th order Butterworth filter and cut-off frequencies of 100 and 14 Hz, respectively. A custom model was set up in Visual 3D (C-motion). GRF, ankle kinematics and ankle moments were extracted for the whole stance phase as well as the first and last 30 ms, designated as early contact (EC) or late contact (LC), respectively. A paired t-test with Bonferroni adjustment was applied to analyse the presented pilot data.

RESULTS AND DISCUSSION
The patches did not affect contact times or maximum vertical GRF of the cutting foot (Fig. 1). There was no significant

![Fig. 1: Ground contact times for the 4 patch conditions.](image-url)
effect on the GRF, ankle kinematics or ankle moments during EC. During LC there was a trend (p<0.1) for a reduced ankle plantar flexion moment (Fig. 2) for the 3 mm wide patch compared to the control condition.

![Fig. 2: Late contact plantar flexion moment for the 4 patch conditions. *: P<0.1.](image)

These preliminary results indicate that the early contact phase is not affected by adding these patches to a handball shoe when performing a cutting move to the medial side. The overall GRF was not affect and movement technique was not altered. During push-off, a reduction of plantarflexion moment may indicate a reduced grip which may potentially affect performance in a handball game. This may indicate that the patch needs to cover more than 1 mm of the edge of the midsole to make any mechanical effect. When getting too wide performance may be affected, while the zigzag patterned patch may be advantageous. No final conclusion may be offered at this stage while the intervention provides some interesting and potentially beneficial results in regard to ankle loading during handball.

It needs to be investigated how different player actions are affected by such interventions. Such future testing needs to include performance relevant measures to attest the applicability to handball training and games.

**ACKNOWLEDGEMENTS**

We have to express our gratefulness to Adidas, Germany, for the provision of the test shoes. Further, we want to thank Thor Grønlykke and Spraino ApS for the provision of the patches. Finally, we would like to acknowledge the help of our handball players for their participation.

**REFERENCES**

Introduction: Ankle sprains are the most common sports injuries. A novel approach is to reduce friction during early contact by adding a slip patch on the lateral edge of the shoe. A previous investigation has shown that Spraino® patches do not affect performance and safety in typical 90°-cutting moves. In this study, the mechanical effects of Spraino® patches for varying cutting angles were explored.

Material and Method: One male participant (age: 44 y, height: 1.95 m, mass: 95 kg) aimed to land with a slightly inverted foot and to vary cutting angle when crossing a force platform. A total of 16 trials were recorded by an 8-camera motion capture system (Qualisys, Oqus) sampling at 500 Hz. A 1-cm patch was attached to the lateral edge of the shoe.
Results: For 15 trials no sliding or substantial reduction in horizontal traction was observed. In only one instance, cross-over cutting at 45° to the contralateral-side, the shoe lost grip and the participant slid off the force plate. In this situation the inversion-eversion moment at the ankle fell to virtually zero completely off-loading the ankle joint. Following this trial, the athlete showed no clinical signs of injury.

Discussion: The reduction of injury-promoting inversion-eversion moments illustrates the potential prevention of ankle sprains in otherwise destructive loading situations. The fact that only one case could be provoked where the athlete lost traction indicates that the use of such patches may be beneficial without compromising player abilities in typical sports games.

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