THE JUMP SHOT - A BIOMECHANICAL ANALYSIS

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SUMMARY
The aim of this study was to measure the extreme physical stress in ankle joint during the push off and landing of the jump shot in handball players. A young handball player a member of the youth national team of Austria (Age 17 years, height 1.80 m, body mass 86 Kg) performed five jump shots. We collected kinematic, kinetic and EMG data. For further analysis the collected data were used in biomechanical modelling and simulation software (SIMM and OpenSIM). The ligaments (fibulotalare anterior =LFTA, fibulotalare posterior =LFTP, calcaneofibulare =LFC) of the lateral ankle were modelled to determine via dynamic simulation the stress in these structures.
The highest load for the LFTP was calculated during landing (58 N) and during takeoff in the LFTA (45 N). This model gives an insight in the load scenario of the ligaments of the ankle. It will assist to develop training methods and help to avoid injuries in young handball players.

INTRODUCTION
The risk of injury is high in handball due to the physical stress and body contacts as the defenders try to stop the attackers from approaching the goal. Most common injuries occur at the fingers and the wrist joint and also at the knee and ankle joint. One of the most important offensive attacking moves is the jumping shot from the backcourt to the goal. The aim of this study is to measure the extreme physical stress in ankle joint during the push off and landing.

METHODS
A young handball player, a member of the youth national team of Austria (Age 17 years, height 1.80 m, body mass 86 kg), performed five jump shots. We used a fixed force plate (AMTI) to collect kinetic data, and a set of 42 reflecting markers on the players' skin for kinematic measurements using ten cameras at a sample frequency of 120 Hz (Motion Analysis Corp.). A simultaneously triggered EMG telemetric system with surface EMG electrodes on the muscles (Vastus medialis, Rectus femoris, Vastus lateralis, Gastrocnemius medialis, Gastrocnemius lateralis) were used. For further analysis the collected data were loaded into biomechanical modelling software (SIMM, MusculoGraphics Inc.) which provides a full body model showing virtual realistic motion [1, 2]. The ligaments (fibulotalare anterior =LFTA, fibulotalare posterior =LFTP, calcaneofibulare =LFC) in the region of the lateral ankle were modelled to determine the stress in these structures via dynamic simulation. The uniform scaling method was used for subject-specific adaption of the model. The placements of the landmarks on each segment were adjusted regarding to present marker positions of representative movements of the subject. The parameters of the ligaments are shown in Table 1.

Table 1: ligament setting for left ankle in SIMM 5.0

<table>
<thead>
<tr>
<th>Ligament in SIMM 5.0</th>
<th>Tendon slack length</th>
<th>Max isometric force</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTA</td>
<td>0.020m</td>
<td>32.4N</td>
</tr>
<tr>
<td>LFTP</td>
<td>0.022m</td>
<td>30.4N</td>
</tr>
<tr>
<td>LFC</td>
<td>0.028m</td>
<td>44.9N</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION
The relative behaviour of the ligament-length over ankle flexion/extension shows consistence to in-vivo studies. The dynamic simulation shows that the lengths of these ligaments change significantly over all recorded motions, especially in the moment of impact. These processes showed qualitative consistence among the different replications of these motions [3]. The stress during landing and take differs significantly (See Figure 1).

In all examples of landing the forefoot had the first contact to ground. This is an unstable condition where a supplementary adduction-supination-inversion-stress (e.g. high static friction between shoe and ground) could result in twisting one’s ankle. The impact of landing makes a muscular proprioceptive reaction of compensation due to its temporal shortness impossible. Secondary, after the first contact, the kinetic energy of the rest of the body, produced by the still downward oriented velocity during the approach and the inertial mass of the body, has to be absorbed with a time lag to the first contact. In a supinated-inverted position of the foot at the first contact this process can result in a supination trauma.

CONCLUSIONS
The processes in a genuine ankle during motion are much more complex and linked to each other than this model can simulate. With all its restrictions this model gives an insight in the load scenario of the ligaments of the ankle. It will assist to
develop training methods and help to avoid injuries in young handball players.

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REFERENCES

Figure 1 shows the loads of the ligaments during takeoff and landing.