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## Biomechanical Determinants of the Jumper's Knee in Volleyball

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**6**

**GENERAL DISCUSSION**

### **6.1. Improving the assessment of knee joint moment in inverse dynamics**

Chapter 2 focussed on possible inaccuracies of the common approach of joint moment assessment in the area of biomechanical research. When calculating the sagittal knee moment of the landing phase in the original way, it shows an impact peak within the first 50 milliseconds. Our data showed that the calculations are based on a wrong approach of the calculation routine for the assessment of knee moment in inverse dynamics, namely to smooth the external force data with a higher cut-off frequency than the position data. Therefore, earlier suggestions about the possible relationship between this first impact peak in the sagittal knee moment and chronic sports injuries like jumper's knee are uncertain and should be reconsidered. Our data support our new proposition for the calculation of the important biomechanical variable net joint moment, namely, that for both force plate data and position data equal filter techniques (cut-off frequencies) should be used before they are used for the calculation of joint moments.

A truthful assessment of joint moment is important, because in biomechanics it represents the load applied to the muscles and tendons located around the joint, and therefore might be a discriminative factor in our search to possible biomechanical risk factors for the development of jumper's knee.

### **6.2. Normative volleyball jump data: Is the spike jump landing the most demanding?**

In chapter 3 a study conducted within high-level amateur male volleyball players is presented. This study was carried out to get a first clear insight into the biomechanical demands of the landing phase after performing volleyball jumps. These volleyball jumps included the defensive block jump performed at the net side and the offensive spike jump. A normalized data set of the ankle and knee joint dynamics was described where both block jump and spike jump were compared to the landing characteristics of a countermovement jump. The latter is often used as a standard jump. The results showed that during the landing after the spike jump both the ankle and knee joint were exposed to higher loads and higher energy absorption than during the landing after a countermovement jump. This was mainly caused by the higher jump height generated during the spike jump. Due to higher segmental velocities caused by the run-up of the spike jump, the muscles are able to produce more work over the first part of the muscle's shortening distance during take-off. The jump height reached after a block jump was lower than after the countermovement jump. In consequence, the participants in this study absorbed less energy with their knees compared to the countermovement jump. This suggests that the block jump might be less dangerous in terms of injury development. Contrary, the load exerted on the quadriceps extensor mechanism in spike jump landing, might be one of the possible risk factors which can be associated with the causal mechanism of chronic injuries, like jumper's knee.

### **6.3. Biomechanical jump and landing characteristics and its relationship with the development of jumper's knee**

For absorbing the kinetic energy during landing without risking a reasonable chance of an injury, appropriate joint flexion is essential and can therefore be considered as a potential risk factor for the development of the jumper's knee.

In Chapter 4 we investigated if there were indications that the landing technique of volleyball players might play a role in the causal mechanism of the jumper's knee. The methodological set up for this study was cross-sectional, where the population consisted of non-symptomatic healthy volleyball players, symptomatic volleyball players with recent patellar tendinopathy (in Chapter 4 and 5 the clinical term patellar tendinopathy is frequently used instead of jumper's knee), and asymptomatic volleyball players with previous patellar tendinopathy. The results indeed revealed some indications that a proper landing technique prevents an athlete from getting injured. More specific, data comparison showed that the previously injured group had a stiffer landing strategy to accommodate the impact forces compared to the healthy players (e.g. a principally higher rate of joint moment development and higher knee angular velocities). Contrary, the recently injured players performed a more pain avoiding strategy, by a decrease of eccentric loads. That the asymptomatic previously injured group showed the highest eccentric loading during landing, suggests that this landing strategy could be a possible risk factor for the development of jumper's knee instead of a behavioural result of the injury itself as it was the case with the recently injured players.

When performing a volleyball spike jump the players load their extensor mechanism eccentrically during two phases, namely during the countermovement phase of the first part of the take-off phase and during the landing. This eccentric loading as risk factor for the development of jumper's knee was the main target in the following study described in Chapter 5. Because in Chapter 4 it was already shown that the outcomes of the landing strategy by recently injured players cannot be related to developmental causes of the jumper's knee, the surveyed population in Chapter 5 only embraced asymptomatic volleyball players with previous patellar tendinopathy and non-symptomatic healthy volleyball players. The results showed generally the same conclusions concerning the landing technique after a spike jump as made in Chapter 4. Data analysis revealed that inappropriate joint flexion during the first part of impact of the spike jump landing and the rate of knee moment development during both eccentric phases of the spike jump-landing sequence can be associated as possible risk factors for the development of jumper's knee in volleyball. For some players in our study other movement characteristics might predisposed them to develop patellar tendinopathy, besides the more general motor behaviour during the eccentric phases of the spike jump-landing sequence as described above. Herewith, the amount of power generation during take-off and a sudden change in training load were suggested as potential additional risk factors for some players.

These findings include additional and deeper insights to the multifactorial risk factors already known (Kannus, 1997; Lian et al., 2003; Ferretti et al., 1990; Richards et al., 1996; Reeser et al., 2006). We recommend trainers and their pupils to pay attention to the possible role of the landing technique on the

development of jumper's knee. It seems that to reduce the incidence of jumper's knee in volleyball, one should aim at a reduction of the rate of load development of the quadriceps extensor mechanism when eccentrically loaded. This can be established by softening the landing by proper ankle plantar flexion and knee flexion. Remarkably, at present trainers instruct their pupils to maximize jump height, but they are generally unaware of the injury risks during landing. One should be aware that in jumps the landing generates even higher forces at the quadriceps extensor mechanism than the take-off phase. An example to accomplish injury reduced landing techniques is the use of a videotape feedback system, as for example already described by Onate et al. (2005).

#### **6.4. Theoretical considerations and recommendations for future research**

It is hoped that the present thesis may contribute to a clearer understanding of the role of the take-off and landing strategy used in the jump-landing sequence in the multifactorial causal mechanism of the jumper's knee. Finding possible risk factors in a cross-sectional study design as presented in this thesis is a relevant and essential step before multifactorial risk factors can be evaluated in a longitudinal study design. Without detracting from the current results, it should be noted that the most preferable approach to study risk factors in chronic sports injuries, is measuring the potential risk factors before the injury occur. All data should therefore be collected in a standardized manner prospectively in time, and should subsequently be guided as ingredients in preventive measures.

In this thesis possible risk factors were found using a cross-sectional study design. Normally, this type of study is limited because of problems in distinguishing between risk factors and injury sequelae when injured participants are compared with their injury-free counterparts (Bahr & Holme, 2005). A key feature in our studies was the categorical division of the jumper's knee patient population investigated. The research activities were planned just before the beginning of the season, in order that asymptomatic volleyball players with previous patellar tendinopathy as well as symptomatic players with current patellar tendinopathy could be included. The performed ankle and knee joint dynamics by the asymptomatic players could therefore theoretically be associated with the development of patellar tendinopathy, instead of been seen as a result of the injury.

Nonetheless, it still can be argued that the landing characteristics of previously injured players are a consequence of the symptoms in the past and have made the player adapt his strategy during eccentric loading. However, it is very unlikely that a load increasing strategy during the eccentric movement as found in Chapter 4 should be related to the symptoms of the injury instead of the risk factors.

The contribution of this thesis is that it gives supplement insight in the jump-landing sequence of volleyball jumps and that some characteristics of these phases may predispose to jumper's knee. A potential next step in the search of the causal mechanism of jumper's knee in volleyball may be that the possible risk factors known from this thesis together with the factors already confirmed by earlier investigations are test variables in a large cohort longitudinal study design, where these variables can be tested in a dynamic multifactorial model (Meeuwisse, 1994; Bahr & Holme, 2005). Within a longitudinal

study, a possible alternative for a full biomechanical analysis of the landing is the use of body-fixed sensors to determine landing characteristics like landing stiffness as suggested in Chapter 4 and 5 of this thesis. The influence of different risk factors can be obtained at different stages in the course of the development of the volleyball player and can give essential information about the mechanisms involved developing a jumper's knee.

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