METHODS

Four collegiate female volleyball players performed volleyball blocks of a ball by moving laterally along a net during fatigued and non-fatigued condition. Fatigued condition started when the athletes were unable to reach 90% of their maximum jump height for three consecutive trials. Sagittal plane kinematics (200 Hz), ground reaction force (1600 Hz) and electromyogram (EMG) (1600 Hz) of seven lower extremity muscles were collected simultaneously. Inverse dynamics was used to calculate net joint moment (NJM) at the ankle, knee, and hip. Binned NJM and normalized integrated EMG were compared within subject between tasks. Significant differences between conditions were tested using analysis of variance ($p < 0.05$).

RESULTS and DISCUSSION

Reaction forces imposed on the lead leg was significantly greater during the fatigued condition than the non fatigued condition for three of four subjects and the mechanical demand (net joint moment) increased for at least one of the lower extremity joints. Muscle activation patterns and EMG levels fluctuated with NJM demands. Co-activation of the knee flexors and extensors was observed prior and immediately after contact to control suggest the impendance-like control (Hogan, 1984, 1985, McNitt-Gray et al., submitted) to accommodate the rapid out-of-phase oscillation of the knee and hip NJMs observed immediately after contact. These subject specific modifications in lower extremity joint kinetics suggest response to fatigue is subject specific and must be considered when attempting to establish a causal relationship between loading and injury.

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Muscle coordination in competitive in-line speed skaters at different skating speeds

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Introduction

Despite the growing popularity of in-line speed skating (ISS) as a competitive discipline, data on biomechanics and skating technique of ISS are still rare (1,3). Especially, muscular coordination patterns are unknown to date, whilst they were studied several times in competitive ice speed skating (2,4). The objectives of this study were to examine coordination strategies of lower extremity muscles in ISS and to detect changes that occur with increasing skating speed.

Methods

Six in-line speed skaters (age: 21,3 ± 3,6 years, National Team Germany) performed a standardized indoor test of graded speed levels on a large motor driven treadmill. Surface EMG data of Medial Gastrocnemius (GA), Gluteus Maximus (GM), Rectus femoris (RF), Semitendinosus (ST), Tibialis Anterior (TA), Tensor Fasciae Latae (TFL) and Vastus Medialis (VM) muscles of the right body side were collected. Changes in EMG burst onset and offset, peak EMG and integrated EMG (iEMG) over functional time periods of the stroke were analysed. Additionally, sagittal plane kinematics and foot pressure distribution were assessed.

Results

EMG burst onset and offset analysis revealed no systematic changes in onset-offset timing with increasing speed. All muscles were active for most part of the stance phase and the main leg extensors showed a proximo-distal activation sequence with a slightly restrained plantarflexion during the sideward push. GM, RF, VM showed two peak activations for all speeds, one at the time when weight transfer occurred and one during lateral push-off. The first peak coincided with a moderate knee extension velocity, the second peak activation with an explosive knee extension during the sideward push. When speed was increased EMG activity during push-off rose significantly for all muscles ($p<0,05$) except for ST, while during the gliding phase only VM, GM, RF and ST showed significant higher activations ($p<0,05$).

Discussion

In-line speed skaters on top level show specific muscular coordination patterns: As previously described in ice speed skating (2) a powerful proximo-distal activation sequence and a restrained plantarflexion during lateral push-off are present in ISS. Furthermore, a second, less explosive push to the medial side during gliding is used by some athletes. This technique, which is referred to as the double-push (5), may account for high ground frictional losses and specific competition characteristics in ISS (e.g. pack skating and drafting) by decreasing stroke frequency and lateral push-off forces for a given skating speed.

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Biomechanical properties of the crimp grip position in rock climbers

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Rock climbers are often using the unique crimp grip position to hold small ledges. Thereby the PIP joints are flexed about 90° and the DIP joints are hyperextended maximally. During this position of the finger joints, bowstringing of the flexor tendons is applying very high load to the flexor tendon pulleys and can cause injuries and overuse syndromes. The objective of this study was to investigate mechanical properties of bowstringing of the flexor tendon sheath. Two devices were built to measure the force and the distance of bowstringing. All measurements of 16 fingers of 4 subjects were made in vivo. The largest amount of bowstringing occurred over the PIP joint (4.3 mm, SD 0.7 mm) during crimp grip position and was caused by the FDP tendon. It was far less (1.75 mm, SD 0.75 mm) during slope grip position (PIP joints being extended). During a warm-up 80 - 100 climbing moves using the crimp grip position were necessary to increase the distance of bowstringing over the distal edge of the A2 pulley by 0.6 mm (30 %). This pulley was loaded about 3 times the force applied at the fingertip during crimp grip position. Load up to 116 N could be measured over the A2 pulley.
In order to evaluate friction between the flexor tendons and pulleys as a possible mechanism of injury, 3 isokinetic movement devices were built where gliding of the flexor tendons along the sheath (pulleys) was involved differently (1. wrist flexion; 2. rolling in movement using the DIP and PIP joint up to flexion of 60°; 3. isolated flexion of the PIP joint between 60° and 100°). Eccentric and concentric maximum forces were measured. The difference between eccentric and concentric maximum force increased from movement device 1 to 3 from 15% up to 25%correspondingly. Therefore an increase of friction is probably apparent between flexor tendons and pulleys during high load application and may explain the mechanism of injury as well as an analogy to the tendon locking mechanism in chiropterans.

Captions to Figures:
Fig. 1: Measuring device for distance of bowstringing.
Fig. 2: Distance of bowstringing (black marked area) of crimp grip (left), crimp grip with isolated FDS activity (middle) and slope grip position (right).
Fig. 3: Isokinetic movement device investigating eccentric and concentric maximum forces during flexion of the PIP joint.