THE INFLUENCE OF INCLINED SUPPORT SURFACE ON THE BIOMECHANICS OF ECCENTRIC OVERLOAD IN SQUATS

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INTRODUCTION

Eccentric overload training, i.e. resisting a moving force that exceeds what the body is able to move concentrically or hold statically, is widely used both for high performance training and for rehabilitation training. At the Elite Sports Center in Bosön, Sweden, a device has been developed to offer eccentric squat training under safe and controlled conditions (Frohm et al. 2005). It consists of a barbell suspended from two steel wires, which is raised and lowered by a hydraulic machine.

Recently, a pilot study on squat training as rehabilitation of patellar tendinopathy has suggested that performing the squat on an inclination board is more efficient (Purdam et al. 2004). The reason indicated is that the inclination board facilitates a technique that gives more load on the knee extensors. This is the hypothesis we have set out to test.

METHODS

The barbell was loaded with 320kg, and the velocity during descent was set to 0.11m/s (unresisted velocity). The subjects stood on two force platforms (60cm × 40cm, 50cm distance center-center; Kistler AG, Switzerland). The movement was measured using a seven-camera motion capture system (ProReflex, Qualisys Medical AB, Sweden) with four reflective markers on the pelvis (ASIS and PSIS), three markers on each of four clusters taped to the thighs and shanks, and markers at the lateral malleolii, the heels and the base of the second phalanxes. Force and motion was recorded on a single PC; data sampled at 2kHz and 200Hz, respectively. Bilateral measurements of the activity of the *biceps femoris, vastus lateralis* and *gastrocnemius* was performed using surface EMG electrodes and recorded on a separate PC with a sampling frequency of 1kHz (Powerlab, ADInstruments Pty Ltd, UK). A single channel of raw force data from the Kistler amplifier was split and fed to both computers to serve as synchronization signal.

Five well trained individuals (18-23years, 60-95kg, 1.70-1.80m) have so far been tested, performing squats in the machine. Starting from the upright position, the subjects were instructed to let the barbell descend about 10cm, and then resist the movement all the way to the bottom position, which corresponded to about 90° knee flexion. During the upward movement, the subjects did not assist nor resist the movement. Four different conditions were tested: Subjects standing either on a horizontal plane or on an inclination board (25° plantar flexion at the ankle), and performing either maximal resistance, or submaximal resistance. The submaximal resistance was instructed to be 80% of the maximal resistance produced isometrically in a squatting position of 90° knee flexion. The submaximal resistance was controlled by providing a visual feedback of the ground reaction force to the subject. A recording was done with the subject in a neutral standing position with extra markers laterally from the knee centers. The centers of the knee and ankle joints were determined with the knowledge of the width of the knees and ankles. The locations of the hip joint centers were estimated from motion capture data (Halvorsen, 2003), taken when the subjects moved their legs using as much of the range of motion of the hip as possible.

In the post-processing step, the data series (3D marker data, force data and EMG data), were aligned in time, saved in C3D files, and analyzed using Visual3D (C-Motion, Rockville, USA). Moments at the ankle, knee and hip joints were calculated using inverse dynamics.

RESULTS AND DISCUSSION

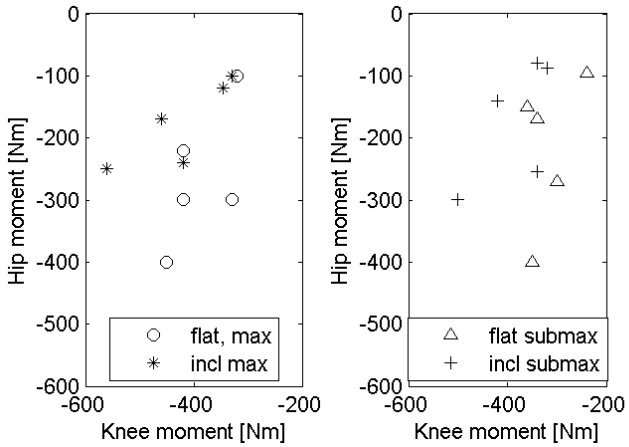

Figure 1 Peak joint moments. Negative values means that an extending muscle force is required.

The most obvious effect that the inclination board has is to remove the limitation that a poor range of motion in the ankle sets on the squatting technique. If the subject cannot dorsi-flex the ankle enough, more flexion at the hip is needed to stay in balance, thus leading to larger moment about the hip and less about the knee. This pattern is indicated in figure 1, with peaks for the inclined squats lying on a higher diagonal line than for flat squats. Two subjects did not exhibit limitation of ankle range of motion, and performed the two types of squats with only small differences in kinematics and joint moments.

REFERENCES

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