LOAD MEASUREMENTS ON THE UTX-ORTHOSIS

N.G.A. van Leerdam, J.C. Cool; Department of Mechanical Engineering, University of Twente, P.O.Box 217, 7500 AE, Enschede, The Netherlands.

A new KAFO, called the UTX-orthosis (UTX = UTIKS = University of Twente Intelligent Knee Stabilization) has been developed. This orthosis stabilizes the knee during the stance phase, but leaves the knee unlocked during the swing phase of gait. Apart from this important functional improvement, the UTX-orthosis is very light (about 750 g). Further weight improvement is, however, still necessary, but for this the maximum loads on the orthosis during use must be known. Therefore three UTX orthoses have been instrumented and calibrated with ordinary strain gauges, so that knee moments in the frontal as well as the sagittal plane could be measured.

During a range of activities of three patients wearing an instrumented UTX-orthosis the moments were measured. Two patients used crutches, one didn’t. Maximum moments were found with the patient walking without crutches. The moments in the sagittal plane are considerably lower (about 10 times) than in the frontal plane. Maximum moments during level walking averaged over a number of strides and normalized to body weight were all found to be flexing and in the range of $6.6 \times 10^{-1}$ to $6.5 \times 10^{-1}$ Nm/kg. Overall maximum flexing moments during each trial were in the range of $6.7 \times 10^{-1}$ to $7.8 \times 10^{-1}$ Nm/kg. The maximum moments during activities other than walking, such as standing up, sitting down, quick turns and floor level differences were slightly higher than during level walking: $7.4 \times 10^{-1}$ to $8.3 \times 10^{-1}$ Nm/kg, flexing. All measured maximum moments however were in the range of the maximum flexing moments presented in literature for normal walking. This indicates that the maximum flexing moments presented for normal walking can, in combination with a suitable safety factor, be used for the design of orthoses.

ELASTICITY IN HUMAN JUMPING

Michael Voigt, Erik B. Simonsen and Pouli Dyhre-Poulsen

Laboratory for Functional Anatomy, Anatomy Dept. C, Institute of Neurophysiology, University of Copenhagen. Denmark.

Elasticity of the series-elastic components of the muscle-tendon complex is important for the mechanical power output. The purpose of this work was to study the validity of the method to quantify muscle-tendon elasticity described by Asmussen and Bond-Petersen (1974) by an integrated biomechanical analysis. Six male skilled jumpers participated in the study. They performed 5 different maximal jumping tasks: squat jumps (SQJ), countermovement jumps (CMJ) and drop jumps from initial heights of 0.3 m (DJ30), 0.6 m (DJ60) and 0.9 m (DJ90). Each type of jump was performed 11 times. The last jump was filmed with 500 frames/sec in the sagittal plane. Maximal voluntary muscle activity (EMG) from 8 muscles in the tight leg was recorded. The imposed negative pre-loads were on average I: 235 J (CMJ), II: 399 J (DJ30), III: 644 J (DJ60) and IV: 877 J (DJ90). There was a significant gain in jumping height of 8% and 10% after imposed pre-load I and II. The positive work output did not show any significant change with changing pre-load, but the average positive power output increased significantly by 36%, 45% and 35% after pre-load I, II, III. The distribution of positive work and average power output over the ankle and hip joints did not show significant changes with changing pre-load. The distribution was: ankles 15%, knees: 65% and hips: 20% both for work and average power output. The estimated reuse of imposed negative work was I: 36%, II: 12%, III: 4% and IV: 8%. The results indicated that the load distribution under the foot and the loading behaviour in general were both speed and to an extent load independent, indicating elastic behaviour. Loss of the plantar aponeurosis and the long plantar ligament generally resulted in a decrease in the loads supported by the metatarsals into which each ligament inserted. The plantar skin also affected the neuro-muscular factors and muscle-tendon mechanics.

IN VITRO MECHANICAL TESTING OF THE LIGAMENTS OF THE HUMAN FOOT

Lloyd T. Walker & Alexander C. Nicol

Bioengineering Unit, University of Strathclyde, Glasgow, G4 ONW, UK.

Four normal feet were tested in a materials testing machine at rates of 4.2 mm/s to 13.3 mm/s and the load distribution under the foot was measured using custom made load cells on a specially designed support platform. Each foot was tested in neutral, 10°, 10° inverted, 10° dorsiflexed and 20° plantar flexed positions. The plantar skin, plantar aponeurosis, long plantar ligament, and musculature and related structures were sequentially removed in a randomised order to indicate their individual effect on foot loading. Three of the feet were also tested in the neutral position to assess the effects of applying tension to the tendons of tibialis anterior, peroneus longus and extensor digitorum longus. Two feet with a hallux valgus deformity were also assessed.

The results indicated that the load distribution under the foot and the loading behaviour in general were both speed and to an extent load independent, indicating elastic behaviour. Loss of the plantar aponeurosis and the long plantar ligament generally resulted in a decrease in the loads supported by the metatarsals into which each ligament inserted. The plantar skin also affected the forefoot load distributions particularly in in- and everted positions. Tension in the tendons of tibialis anterior and peroneus longus shifted the forefoot force distribution to the lateral and medial sides of the foot respectively while tension in the extensor digitorum longus tendon transferred forces posteriorly. Tests on the two feet with hallux valgus confirmed the biomechanical changes due to the loss of the "windlass" effect of the plantar aponeurosis around the first metatarsal head. Load was generally transferred away from the medial side of the foot. There were also indications that the medial interosseus and related ligaments had been permanently stretched as a chronic effect of this condition, due to overloading of the medial arches.