CINEMATIC ANALYSIS OF THE ANKLE AND SUBTALAR JOINTS RELATED TO THE MYOELECTRIC ACTIVATION PATTERNS IN JUMPING EXERCISES UNDER INCREASE STRETCHING LOADS.

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INTRODUCTION

Rearfoot mobility around the Subtalar joint during the support phase of running has been extensively studied. The cinematic analysis of this movement was first reported by Nigg et al. (1978) and Bates et al. (1978). In the further studies. the amount of eversion (pronation) and inversion (supination) was often related to stress injuries on Tibialis Anterior and Achilles tendons, ligaments and soft tissue (Nigg et al. 1986; Edington et al. 1990). The pronation-supination cycle of the subtalar joint occurs in every active support phase, and is present on the contact phase of jumping movements. In a spread number of jumping exercises, large mechanical load is present during the pronation-supination cycle. This load produces high tension levels on the muscle-tendon complex increasing the risk of injury.

Muscle and tendon stress depends on the mechanical load and on the relation between the activation levels of the muscles and angular velocity around the joint (Denoth 1986). The association of neural activation patterns of the muscles involved in subtalar and ankle movement, together with the cinematic parameters, usually used to studied the rearfoot mobility. seems to be an attractive way to investigate the possible control mechanisms responsible for these movements.

The purpose of this study was to investigate the influence of stretching load on subtalar movements and on the EMG patterns, during drop jump exercises.

METHODS

Five adult elite sprinters (age 27±4; height 175±5.5 cm ; body mass 72.8±6.8 Kg) performed drop jumps under three load conditions: drop from the height of 40 cm, 55 cm and 70 cm. The subjects were instructed to perform reactively, always keeping their hands on their hips.

The signals from Force Plate, Knee and Ankle electrogoniometers, and Surface EMG were A/D converted at 1000Hz (Biopac-MP100). The EMGs of Gastrocnemius (GAS). Soleus (SOL). Tibialis Anterior (TA) and Peroneus Longus (PL) were filtered, fullwave rectified and smoothed. TA is the main inverter and also dorsiflexor, PL is the main everter and also plantar flexor and triceps surae (GAS and SOL) is the main plantar flexors (Stacoff & Luethi 1986).

The EMGs were integrated (iEMG) over different functional phases: Preactivation (PRE) (100 ms before touchdown(TD)), Eccentric phase (ECC) from TD to maximal angular position (MAP) and Concentric phase (CON) from MAP to push-off.

The right foot and leg were filmed from behind at 50 fields/s. A digital clock connected to the A/D card was filmed allowing the synchronisation of the film and EMG data.

The co-ordinates of the four markers. placed on rearfoot and lower leg, were digitalized using a high resolution (1092/756) frame grabber and customised software. For each subject the angle between rearfoot and lower leg markers, the Achilles tendon angle (AqTA), was measured on neutral standing position (angle of 0 degrees) and subtracted from all subsequent dynamic measurement. As we have used a reduced sampling rate (50 Hz) only relative measurements were considered: de total amount of pronation ($\Delta AqTA$), the period of pronation (Δt PRO) and maximal (MaxPROve) and average (AvgPROve) pronation velocities.

Each drop jump was performed five times. The signals from each jumping condition were time-normalised and the EMGs were also normalised in amplitude for each subject. After normalisation force, angle position and EMG signals were averaged for each jumping condition. The final results were presented as grand means calculated for all five subjects. This procedure makes possible direct comparison between the different conditions, filtering out the individual behaviour.

RESULTS AND DISCUSSION

The results of the ankle and subtalar movements for each jumping condition (Fig 1), showed that the eccentric period (Δt ECC) is basically simultaneous with the pronation period (Δt PRO). Both parameters decreased as the stretch load increases(fig. 1). Amplitude, maximal and average velocities of pronation increased with stretch load. The values obtained for MaxPROve were similar to those reported by Williams & Ziff (1991) for running.

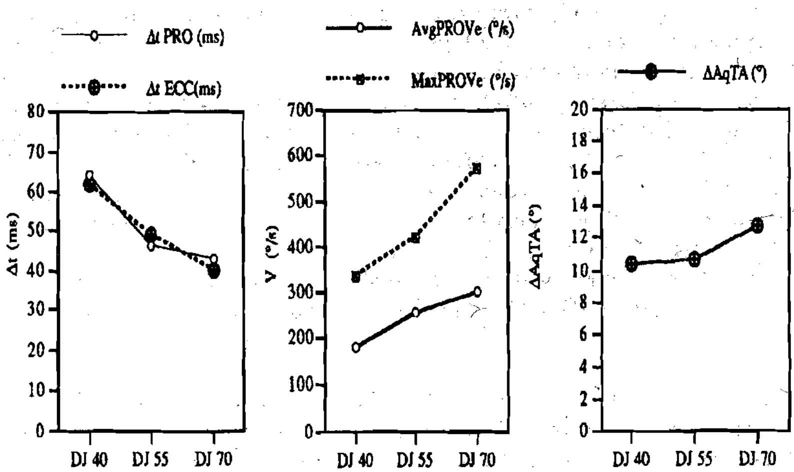

Fig. 1- Left to right, eccentric (Δt ECC) and pronation (Δt PRO) periods; average(AvgPROve) and maximal (MaxPROve) pronation velocities and total amount of pronation ($\Delta AqTA$), for each jumping condition.

The iEMGs of the Preactivation phase increased with the stretching load in all of the studied muscles (Fig.2).

During preactivation, EMG amplitudes of GAS and TA, were relatively high, suggesting a cocontraction phenomenon (fig 2), which could increase muscles stiffness during the early impact phase. At touchdown, the foot was in plantar flexion and supinated. Immediately after touchdown the foot was forced to an eversion (pronation) were a high activation level of both GAS and TA could be observed, which could create large stress on muscle tendon complex.

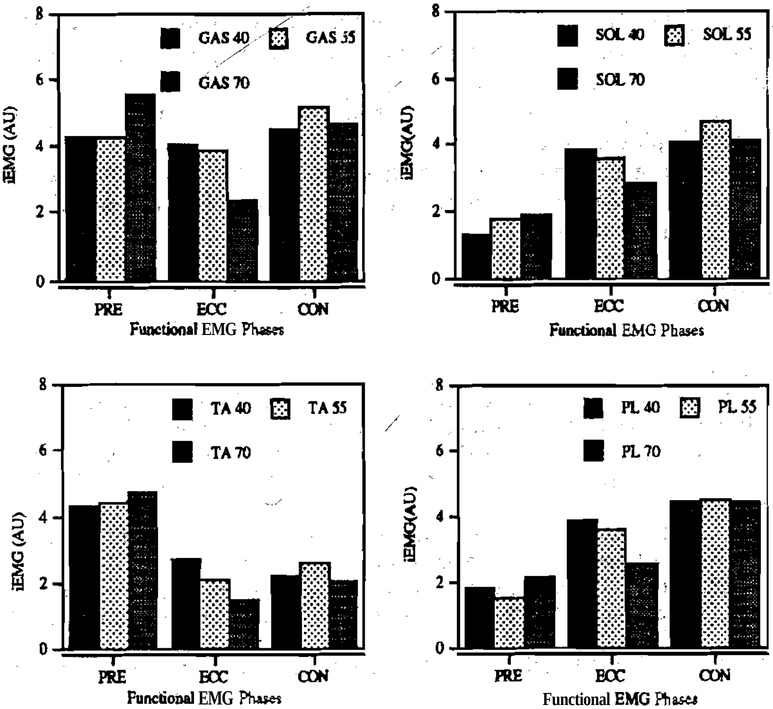

Fig. 2- iEMG of gastrocnemius (GAS), soleus (SOL), tibialis anterior (TA) and peroneus longus (PL), expressed as percentage of maximal EMG peak in DJ 40 (arbitrary units), for the tree different functional phases.

During the ECC phase, the activation levels decreased with the increase of stretch load, mainly in DJ70. In our previous study (Santos et al. 1994). in which the raw data were the same of the present study, the force length relationship was investigated for the triceps surae muscles. The results of the above mentioned study, showed a positive energy balance only for the lowest stretch load. At DJ40 the impact energy was absorbed by the muscle-tendon complex and delivered during push-off. At DJ70 a negative balance was obtained. This observation could explain the decrease of the iEMG observed for the ECC phase of DJ70.

The EMG patterns of PL and SOL were similar. Both muscles had a relatively smaller preactivacion level than TA or GAS, and being increasingly actives on ECC and CON phases. Apparently PL acts, during ground contact in jumping, mainly as a plantar flexor.

CONCLUSIONS

The results obtained showed that the parameters associated with the subtalar joint movement, are influenced by the mechanical load in jumping exercises. Especially, maximal and average pronation velocities increase with stretch load.

The EMG of preactivation was, also, load dependent, indicating that, the expected stretch load as an important role on preactivation regulation.

Tibialis anterior worked as a foot lateral stabiliser. During the pronation period of the contact phase, TA was stretched at height angular velocities, as a function of mechanical load increase. Considering that TA was highly preactivated, the stress on its tendon would also increases with the stretching load.

Gastrocnemius was also highly preactivated, and consequently the increase on the ΔAqTA ,AvgPROve, and on MaxPROve could also represent an increased stress on Achilles tendon.

The EMG of Soleus and Peroneus longus presented a similar pattern, suggesting that PL acts mainly as a plantar flexor.

The fact that the pronation and eccentric phases occurred simultaneously suggest that the rotations over the subtalar and ankle joints are common tridimentional movement involving both joints.

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