REFLEX RESPONSES AND ANKLE JOINT LOADING DURING PERTURBED TURNING MOVEMENTS

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INTRODUCTION

Lateral sprains of the ankle are among the most common injuries occurring during landing or cutting movements with or without interference of an object or opponent. Although considered to be a minor injury a high proportion of complications and associated costs result (Larsen et al., 1999). Risk factors, such as foot shape or playing surface as well as the effect of interventions, such as bracing or training reveal partially contradictory results. The underlying injury mechanisms are not yet fully understood (Bahr & Krosshaug, 2005), and well controlled epidemiological studies and experiments are needed.

A previously developed robotic platform allows for fast and controlled perturbations around four degrees of freedom (van Doornik & Sinkjær, 2007) to a force platform. This device is fast enough to simulate varied amplitudes and velocities of sliding as observed on different surfaces.

The purpose of this study was to assess muscle activity, joint kinematics and loading in perturbed turning manoeuvres.

METHODS

Thirteen subjects were asked to carry out 180 degree cutting moves while making contact with the robotic plate. The plate was covered with rubber to generate maximum friction between shoe and surface. Randomly, five conditions of the platform moving in run-up direction were applied immediately after making contact. Amplitudes ranged from 0 - 6 cm over times of 121 or 242 ms (ST=still, SS=3 cm slow, SM=3 cm medium, LM=6 cm medium, LF=6 cm fast). Ground reaction forces (GRF), electromyographic (EMG) data from eight lower extremity muscles (2000 Hz) and 3-dimensional kinematics (Qualisys, 250 Hz) were recorded. The muscles were: tibialis posterior, soleus, peroneus longus, both gastrocnemii at the leg and vastus medialis, rectus femoris and biceps femoris at the thigh. A lower extremity model (AnyBody) was set up to calculate ankle joint kinematics and resultant joint loading. A repeated measures ANOVA was used applying a Newman-Keuls test for post-hoc analysis. The level of significance was set to $p < 0.05$ for all statistical measures.

RESULTS AND DISCUSSION

Horizontal braking forces in the first third of ground contact as well as force rates decreased with increasing slip magnitudes and velocities. Total horizontal power generation was highly individual varied only marginally with slipping, demonstrating a significant reduction only for LM against ST (6%). Inversion torque (maximum within the first third of contact) was significantly reduced for conditions SM and LF (Figure 1). It was consistently perceived by subjects that the no slip trials (ST) were hardest and most demanding with regard to strength requirements. This observation was confirmed by ST also showing the longest contact time. Thus it may be concluded that a certain amount of slip during the initial ground contact phase can be beneficial from a performance as well as from a safety point of view.

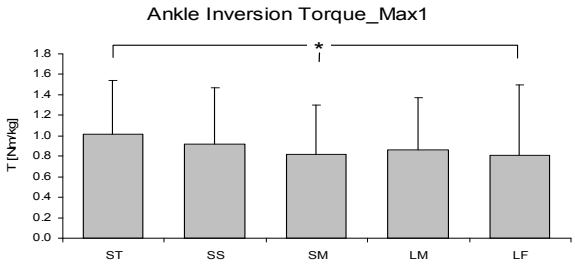

Figure 1: Changes of ankle inversion torque in the first third of ground contact.

Foot positioning and pre-activation levels of all muscles were similar across slip conditions indicating that subjects did not show any changes in approach through this experiment. Surprisingly, no clear reflex responses as well as no modulations of muscle activity in a time window of 50 – 120 ms after touch-down were observed for the peroneus longus. It would be expected that this muscle group experiences a fast elongation in the early contact phase which in turn would lead to a reflex response (Robbins &Waked, 1998). Thus it was concluded that perturbations of the kind applied here would not provoke an increase of peroneal activity and therefore not change the lateral muscular stabilization of the joint.

A method for calculating GRF on a moving force plate was applied. This experimental approach may be helpful in better understanding the mechanisms involved in acute ankle injuries. However, it might be questioned if the movement patterns of the platform resemble what happens during slipping on various sports surfaces.

CONCLUSIONS

This study demonstrated that a certain amount of initial slip might be beneficial from performance and injury prevention perspectives. It may be possible to design surface-footwear combinations which optimize both aspects.

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