TRANSMISSION OF CONTROLLED EXTERNAL PLANTAR IMPACTS ALONG THE TIBIA IN RELATION TO MUSCULAR ACTIVITY

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INTRODUCTION

The shocks transmitted to the musculoskeletal system from external ground reaction impacts have been described as responsible for a number of musculoskeletal pathologies including tibial stress fractures, knee and hip osteoarthrosis and lower back problems [1]. The aim of this study was to ascertain the relationship between lower leg muscle activity and *in vivo* accelerations measured at distal and proximal tibial sites. Previous studies have primarily investigated the relationship between external gorund reaction force and a single proximal tibial site [2] or across joints. These designs exclude the parameter of shock transmission along a single long bone and the possible damping effect of muscle stiffness. In order to avoid the uncertain influence of complicating factors encountered in a previous study [3] in which tibial acceleration transmission was determined during running, this study was restricted to very controlled, static trials.

METHODS

Six voluntary male healthy subjects participated in this study and the data of one subject (36 year, 88 kg) are presented in this abstract. Tibial accelerations were measured using 3D accelerometers (Kistler®, mass <2.5 g) attached to Apex® pins (diameter 3.0mm, length, 60mm) inserted approximately 1.5 cm into the distal and proximal tibia. Pin insertion was conducted under local anaesthetic and the experimental protocol was limited to three hours. Surface electromyography (EMG) electrodes recorded the activity of the gastrocnemius medialis (GM) gastrocnemius lateralis (GL), soleus (SOL), tibialis anterior (TA) and intramuscular EMG wires were used for tibialis posterior (TP). The summed integral of the EMG linear envelopes was referred to as the tibial muscle envelope. A custom made pneumatic impacter initiated impacts under the heel. The ankle joint was maintained in 90º and the knee angle at 180º (full extension). The impact force (F) was measured with a one dimensional force transducer (Kistler®). The sampling rate for all analog data was 1000Hz. Maximal voluntary isometric contractions (MVC) for each muscle were performed and to control muscle pre-activation three activation levels were defined at 0%, 30% and 60% of the MVC EMG amplitudes for GM and vastus medialis (VM). Ten impacts were initiated at each activation level. Accelerometer axes were mathematically aligned with the anatomical tibia axis using a correction algorithm based upon reflective markers recorded by a movement analysis system (ProReflex®, Qualysis, Sweden). F and the tibial accelerations were compared for the three activation levels and the effect of the tibial muscle envelope (sum of EMG integrals 50 ms prior to 50 ms after impact) upon the shock transmission from distal (accTD) to proximal tibia (accTP) was investigated (figure 1). Shock transmission was calculated as accTD – accTP. ANOVA and correlation statistics were calculated in Statistica®.

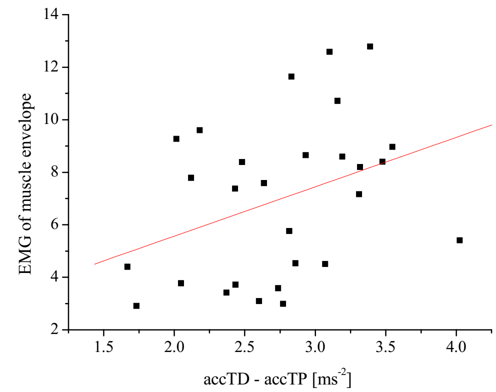

Figure 1: Scatter plot of acceleration damping (accTD-accTP) vs summed EMG integrals of the tibial muscle envelope: r = 0.36, p = 0.06. Two trials were not accepted due to knee angle variation.

RESULTS AND DISCUSSION

Significant differences ($p \leq 0.05$) in F and accTD were found between the 0% and 30% and the 0% and 60% levels, accTP was not significantly influenced. F and accTD correlated significantly with the tibial muscle envelope activity (r = 0.77 and 0.62 respectively, $p \leq 0.05$), accTP did not. Figure 1 shows that the transmission from distal to proximal tibia was not significantly correlated with muscle envelope activity. A trend towards increased damping was, however, shown (r = 0.36, p = 0.06), and it remains to be seen how the inclusion of further subjects in the analysis influences this result.

CONCLUSIONS

The very controlled nature of the external impacts combined with the accuracy in orienting the accelerometer axes provided prerequisites for precise description of shock transmission. The data are an important contribution to the understanding of musculoskeletal control and also raise questions concerning previous studies where accelerations were only measured at one tibial location.

REFERENCES

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