INTRODUCTION

The transmission of vibrations or shocks along single body segments or across joints is often implicated to overuse injuries (tennis elbow, tibial stress fractures, osteoarthritis). However, only little is known concerning the mechanism of shock transmission along the skeleton (Whittle ’99; Hennig ’91). Due to artefacts caused by soft tissue movements the use of skin mounted accelerometers is not a promising approach in this perspective. Therefore the purpose of this study was to quantify the transmission of vibrations from the proximal aspect of the tibia via the knee joint to the distal aspect of the femur in vivo.

MATERIAL AND METHODS

Four male volunteers participated in this study (age: 18-40 years, mass: 77-89 kg). In order to analyse the mechanism of shock transmission during running two miniature piezoresistive accelerometers (Kistler piezotron, 8694M1; mass: 2.5 g) captured tibia and femur acceleration. To eliminate skin movement artefacts two Hoffman bone pins (diameter 3.0 mm, length, 60 mm) were used. Under local anaesthetic one pin was inserted with the complete thread into the lateral condyle of the tibia and the second into the lateral condyle of the femur. After insertion an accelerometer as well as a marker array for kinematic analysis was attached on each pin. The subjects ran with a self selected speed under three different shoe conditions (2.8 m/s ± 0.3) with one heelstrike of the analysed leg on a Kistler force platform. Three valid trials of each subject under each condition were examined. Ground reaction forces (GRF) and acceleration data were sampled with 2500 Hz. The natural frequency of the instrumented bone pin was experimentally determined being over 120 Hz. The acceleration data was filtered by means of a FFT bandpass (cut off 1 Hz and 100 Hz). Using the vertical GRF as trigger (10 N threshold) 75 ms after heel contact were analysed. To asses the shock transmission the ratio (a_rat) of the peak acceleration at the femur (a_fem) in percentage of the peak acceleration at the tibia (a_tib) was calculated for each trial. The time difference (t_diff) between a_tib and a_fem was also determined. Since the FFT bandpass could lead to a time shift of the acceleration data the values for t_diff were analysed in 10 ms intervals while differences below 10 ms were neglected. An ANOVA was calculated to identify inter-individual differences between the observed parameters as well as to exclude the influence of the different shoe conditions.

RESULTS AND DISCUSSION

On a 5% level the ANOVA revealed no significant differences between the shoes in a_rat, a_fem, a_tib and t_diff. Fig 1. shows the averaged time histories of a_tib and a_fem for two subjects. The curves point up differences regarding the shock transmission patterns between the two subjects. For subject 2 tibia and femur accelerations show good congruence within the first 100 ms. In subject 1 the femur data shows a different pattern concerning the magnitude of a_fem as well as t_diff. For subjects 2, 3 and 4 t_diff was below 10 ms for every trial and therefore was neglected. For subject 1 it was between 10 ms and 40 ms in all cases. The ANOVA for a_rat revealed significant differences between three groups of subjects (Fig. 2).

REFERENCES