CHANGE OF KINETIC LOWER EXTREMITY JOINT VARIABLES DURING UP- AND DOWNHILL WALKING ON DIFFERENTLY INCLINED SLOPES

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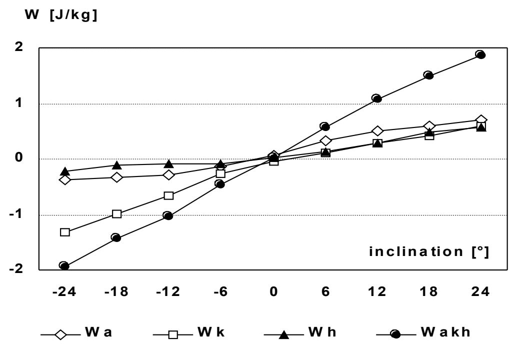
INTRODUCTION: Lower extremity joint loads in level and downhill walking are reported in several papers (e.g. Kuster et al., 1995, Schwameder et al., 2000). The change of load distribution, however, between the ankle-, knee- and hip joint depending on slope inclination in up- and downhill walking are still not sufficiently presented. Thus the purpose of this study was to determine kinetic variables at the three main lower extremity joints as a function of both, declination and inclination of the slope.

METHODS: 22 healthy students (28 ± 4 years, 1.76 ± 0.08 m, 72.5 ± 12.1 kg) were asked to walk on a ramp with an integrated force platform at different grades. Both, the ramp and the force platform were adjustable to de- and inclinations from –24° to +24° in steps of 6°. 2D kinematic data (sagittal plane) were collected using a video camera located perpendicular to the ramp. 7 body landmarks (heel, ball, toe, ankle, knee, hip, shoulder) during one stance phase were digitized manually. The filtered and time-normalized kinematic and kinetic data were synchronized and the two local coordinate systems were aligned during the data analysis process. Standard inverse dynamic procedure was used to calculate sagittal planar net forces (F_j) and net moments (M_j) at the ankle, knee and hip joint. Mechanical joint power (P_j) was calculated by $P_j = M_j\ \omega_j$. The total work done by the muscles of each joint W_j was determined by the time integral of P_j over the whole stance phase.

RESULTS AND DISCUSSION: Both, peak values and time courses of the kinetic variables determined change substantially and in most cases significantly in walking on different grades. The results are in line with data presented by Kuster et al. (1995) and Schwameder et al. (2000) for downhill walking at 11° and 25° and level walking, respectively. Net work done by the muscles around the ankle (Wa), knee (Wk) and hip joint (Wh) as well as the sum of these components (Wakh) increase from downhill to uphill walking continuously (Figure 1).



In downhill walking total work is negative during stance phase at each joint, while in uphill walking total work is throughout positive. During downhill walking most of the energy is absorbed by the knee joint and the percentage increases with the declination of the slope. The highest amount of energy in uphill walking is generated by the ankle joint.

Figure 1 - Total work at the ankle-, knee- and hip joint as a function of inclination in walking.

CONCLUSION: Loads on the lower extremity joints are distributed differently during up- and downhill walking depending on the inclination of the slope. Especially the contribution of the knee joint muscles to energy absorption in downhill walking is affected by the declination of the slope. These results may help to find an optimal combination of stimulating biological structures and preventing them from overloading primarily in rehabilitation training.

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