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Title: The role of muscle strength capacities for knee kinematics during downhill hiking with total knee arthroplasty after a training intervention

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INTRODUCTION:
During downhill hiking, people with unilateral knee arthroplasty (uKA) show muscular deficits and stiff knee gait patterns compared to healthy controls [1]. We hypothesized that a 12-week training intervention counteracts the muscular deficits and that the muscular improvements contribute to more physiologic knee joint kinematics during downhill hiking.

METHODS:
Thirty-five participants (266 ± 87 days post surgery) with uKA (INT) conducted a 12-week muscle strength training intervention (3 training sessions á 45 minutes per week). Before (PRE) and after (POST) the intervention, the following measurements took place: Participants walked on a predetermined walking trail at a self-selected pace wearing an inertial sensor system (XSens, Awinda, Enschede, Netherlands) to record the 3d kinematics of the lower extremities. We evaluated the peak knee flexion (PKF) and the range of motion (ROM) of the affected leg during shock absorption (25% of the gait cycle) at two different down-slopes (10% and 25% gradient). In addition, we measured the concentric and eccentric lower extremity isokinetic muscle strength (Isomed2000, D. & R. Ferstl GmbH, Hemau, Germany) of the knee flexors and extensors of the affected leg at two angular velocities (50°/sec, 120°/sec). Fourteen controls with uKA, matched for age, BMI, and days since surgery, were also measured; however, they did not perform the training intervenetion program (CON).

RESULTS:
Muscle strength (identified as body mass normalized peak torque; Nm/kg) improved significantly from PRE to POST for both muscle groups and all tested conditions by 10-47 % (INT) and by 3-25 % (CON) ($p < 0.05$). PKF and ROM while walking downhill at the moderate slope increased from 18.3 ± 8.6 to 22.6 ± 9.3 (PKF) and 11.8 ± 4.2 to 14.4 ± 4.2 (ROM) in INT and from 18.6 ± 7.3 to 21.9 ± 4.5 (PKF) and 12.1 ± 3.7 to 15.7 ± 3.2 in CON ($p < 0.01$). Concerning the steep slope, values developed from 25.6° ± 7.7° to 27.5° ± 6.8° (PKF) and 14.9° ± 4.0° to 16.6° ± 4.2° (ROM) in INT and from 22.9° ± 8.3° to 23.4 ± 5.5 and 13.8 ± 3.6 to 16.0 ± 2.3 in CON ($p < 0.01$). No interaction effect between time and group was found ($p > 0.05$). Improvements in hamstrings and quadriceps strength values were correlated positively with ?PKF (PKF POST-PKF PRE) and ?ROM (ROM POST-ROM PRE) at both downhill slopes in INT. Parameters correlated less in CON.

CONCLUSION: Muscle strength improvements played a significant role in developing more physiologic knee kinematics during downhill hiking in persons with uKA. However, the lack of time by group interactions for strength improvements indicate that the additional strength training program might not have significantly increased strength capacities compared to standard rehabilitation, highlighting the potential for future studies using more intense or more prolonged training intervention.

[1] Bleuel et al. (2024). Clin Biomech. Funding: Dr. Auguste-Schaedel-Dantscher-Stiftung, Deutsche Kniegesellschaft