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In-toeing gait requires less muscular effort and reduces lower limb joint loads in people with internal torsional deformities

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1. Introduction

Femoral and tibial torsional deformities are common in patients with and without neurological disorders [1]. Torsional deformities increase joint loading in people with typical foot progression angle (FPA) [2]. Many people with torsional deformities walk with an in-toeing gait, i.e. reduced FPA [3]. Little is known about the reasons for in-toeing gait and the effect of torsional deformities on muscular effort.

2. Research question

(1) How do torsional deformities effect muscular effort and joint loading during walking?
(2) How does in-toeing gait effect muscular effort and joint loading in a patient with torsional deformities?

3. Methods

Three-dimensional gait analysis data (3DGA-data) of a person with typical bones and walking pattern (FPA external 8°) and a patient with torsional deformities (45° anteversion and 2° of tibial torsion) and in-toeing gait (FPA internal 12°) were analyzed. For research question 1, we created musculoskeletal models with a variety of femoral and tibial deformities (±20° in 10° steps) [4,5]. With each model we tracked the typical 3DGA-data to quantify how torsional deformities affect joint kinematics, muscular effort and joint loading. For research question 2, we created a patient-specific musculoskeletal model and tracked the typical and pathological 3DGA-data to quantify how in-toeing gait affects muscular effort and joint loading. Joint kinematics, muscle activation and forces, and joint contact forces (JCF) were calculated in OpenSim [6] and compared between different models.

4. Results

Internal femoral and tibial deformities led to increased external hip rotation, increased overall muscular effort and increased hip and knee JCF when tracking the typical 3DGA-data (=normal FPA). External femoral and tibial deformities led to internal hip rotation and only had a minor impact on muscular effort and JCF. In our patient with internal torsional deformities, in-toeing gait decreased the muscular effort and hip and knee JCF compared to the walking pattern with typical FPA.

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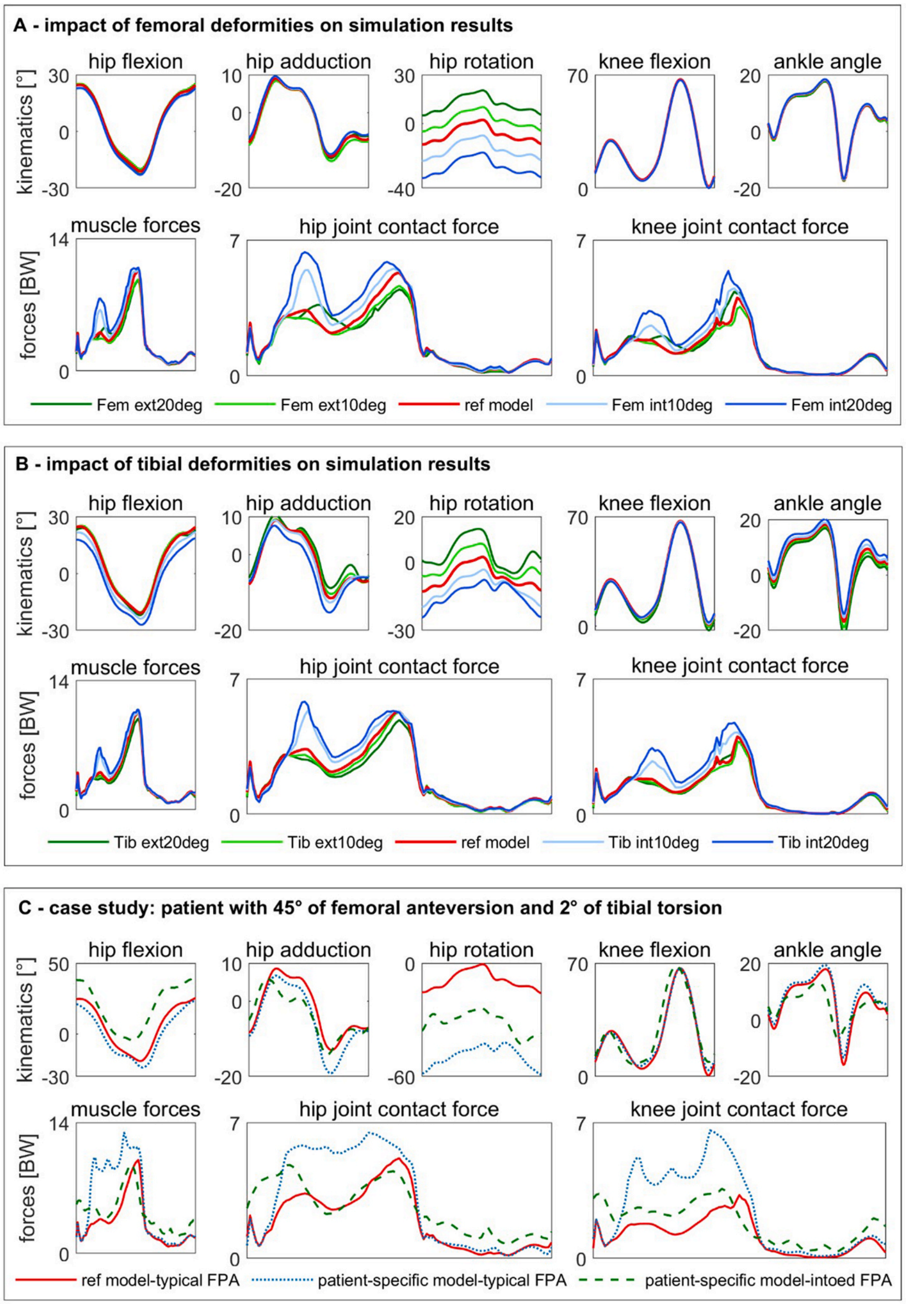

5. Discussion

Our study showed that walking with a typical FPA requires more muscular effort and increases JCF in people with internal torsional deformities. Two factors cause this increased muscular effort: (1) increased external rotated hip decreased the moment arms of hip rotator muscles (24% decrease in our patient) and (2) hip rotator muscles have to contract more and therefore produce a force further away (14%) from their optimal fibre length. Hence, substantial higher (2.9 times) muscle activations are required to achieve a typical FPA, which is unlikely to be sustained over a long period. In-toeing gait decreased the muscular effort and joint loading, which is likely the reason why many people with internal torsional deformities choose this walking pattern.

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