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ON THE BIOMECHANICAL RELATIONSHIP BETWEEN APPLIED HIP, KNEE AND ANKLE JOINT MOMENTS AND THE INTERNAL KNEE COMPRESSIVE FORCES

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BACKGROUND

Medial knee osteoarthritis is often treated using a valgus brace [1], which has the purpose of shifting the internal joint load from the damaged medial cartilage and meniscus laterally. Many studies claim a medial load reduction based on a reduced knee adduction moment [2,3] even though this correlation has been shown to be fairly low [4] and, even if the load shift succeeds, this approach does not reduce the total compressive knee load.

AIM

To investigate how internal knee joint loads depend on applied moments during gait and hereby gain insight into how to reduce the total compressive knee load.

METHOD

Musculoskeletal (MS) models (see Figure 1), from a previous study [5], were used, including ten healthy subjects (8 males and 2 females, age: 25.7 ± 1.5 years, height: 180.8 ± 7.4 cm, weight: 76.9 ± 10.4 kg) who performed three gait cycles (GCs) each. The models were developed in the AnyBody Modelling System (AMS) and driven by full-body 3D kinematics based on trajectories from 35 surface-mounted reflective markers (29 placed on the skin and three on each shoe).

The AMS was used to compute muscle and joint forces while applying joint moments in the lower extremity at the hip, knee and/or ankle, in both sagittal and frontal plane, which completely balanced the internal moment, to investigate which moment(s) potentially contribute the largest reduction of the total compressive knee joint load.

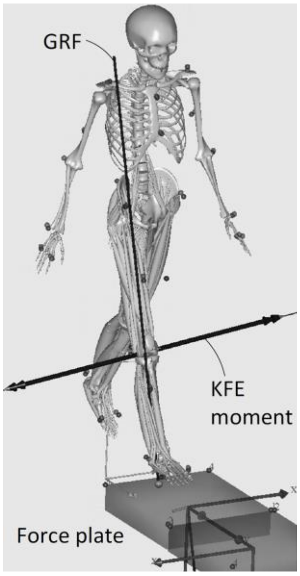

Figure 1. The used MS model in AMS applied with an ideal knee flexion-extension (KFE) moment to counteract the internal moment. The person steps on force plates measuring the ground reaction force (GRF).

RESULTS

Figure 2 shows the mean knee compressive load during stance phase (0-70% GC) for each combination of applied moments in the sagittal plane and also varus-valgus moment for comparing with a valgus brace.

Our results indicate the highest internal knee load reduction when applying moments in the sagittal plane and when combining these, the reduction increases. All mentioned reductions are with respect to normal gait, which represents the compression load when no moment is applied (Normal). When combining flexion-extension (FE) moments in hip, knee and ankle (Hip+Knee+Ankle), the first peak (~13% GC) and second peak (~50% GC) were reduced 52% and 60% respectively. Hip+Knee reduces both the first and second peak significantly with 56% and 30% respectively, whereas Knee+Ankle performs better at second peak with a reduction of 35%.

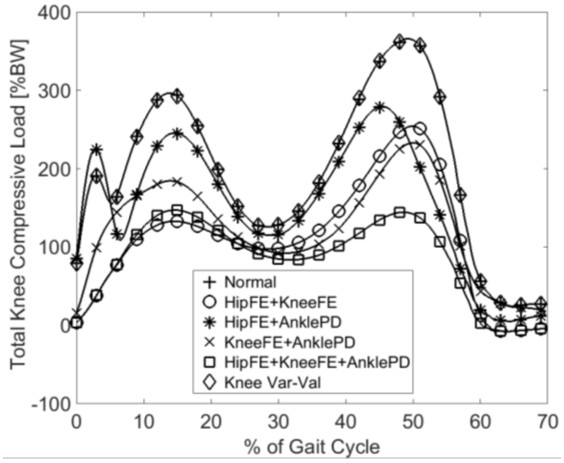

Figure 2. The mean total knee compressive load as percentage of bodyweight (BW) during stance phase for each combination of applied moments in sagittal plane and varus-valgus moment, which overlaps Normal. FE=flexion-extension and PD=plantar-dorsi flexion

DISCUSSION & CONCLUSION

The study indicates that the total compressive knee load is not affected by a varus-valgus moment whereas applied moments in the sagittal plane contribute more effectively to this reduction due to reduced muscle forces. The applied moments in this study completely balance the internal moments which is not feasible in practice. However, the results show which approach, of the investigated moments, most efficiently reduces internal joint loads. This can be used as guiding for improving current knee braces.

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