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HOW INTERNAL KNEE COMPRESSIVE FORCES ARE MOST EFFECTIVELY REDUCED BY APPLIED HIP, KNEE AND ANKLE JOINT MOMENTS

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INTRODUCTION

Valgus or varus braces are often used as treatment for unicompartmental knee osteoarthritis (KOA) with the purpose of shifting the internal knee load from the damaged cartilage and meniscus to the other compartment. The majority of KOA patients suffer from medial cartilage deterioration [1] for which reason a medial load reduction is usually the main goal with brace treatment. This goal is often claimed to be reached in the literature based on a reduced knee adduction moment [2,3] despite a fairly low correlation between these two parameters has been shown [4]. Whether or not the brace succeeds to shift the load, the total compressive knee load is still unaffected. Thus, we wanted to investigate how internal knee joint loads depend on applied moments during gait to obtain information on how to reduce the total compressive knee load most efficiently.

METHODS

The study is based on musculoskeletal (MS) models, from a previous study [5], which included 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). For each subject, full-body 3D kinematics were recorded during three gait trials based on 35 surface-mounted reflective markers (29 placed on the skin and three on each shoe). The trajectories from these were used to drive MS models in the AnyBody Modelling System (AMS), which computed muscle and joint forces while applying joint moments, completely balancing the internal moment at the hip, knee and/or ankle, in both the sagittal and frontal planes. The total compressive joint load was examined for each applied moment and those contributing to the largest load reduction was combined to find the most effective combination of those tested.

RESULTS AND DISCUSSION

The effect on the mean total compressive load during the stance phase and early swing (0-70% gait cycle) from combinations in the sagittal plane, applied varus-valgus moment (KneeAA) and normal gait without any applied moments (Normal) is shown in Figure 1. The curves indicate moments in the sagittal plane to be most efficient regarding knee joint load reduction, which is assumed to be due to compensation of the internal moment from muscle contraction, which are completely balanced by the applied moments. While a complete unload of the muscles is not ideal in practice, the results indicate which approach, among the investigated moments, most efficiently reduces internal joint loads.

In the following, all comparisons are based on the curves in Figure 1 with respect to Normal. The applied moments are referred to as FE (flexion-extension), PD (plantar-dorsi flexion) and AA (abduction-adduction).

A combination of hip, knee and ankle moments in the sagittal plane (HipFE+KneeFE+AnklePD), reduces the first peak (~13% gait cycle) and second peak (~50% gait cycle) with 52% and 60%, respectively. HipFE+KneeFE mainly affects the first peak with a reduction of 56% and KneeFE+AnklePD performs slightly better on the second peak than HipFE+KneeFE with a reduction of 35%. It is worth noting that the KneeAA curve (simulating the effect from a varus or valgus brace) coincides with the Normal curve since this moment only shifts the condyle load.

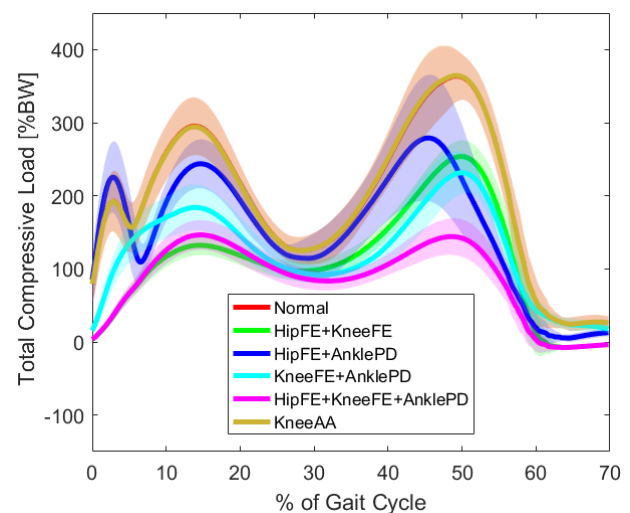


Figure 1: The mean total knee compressive load as percentage of bodyweight (%BW) from 0-70% gait cycle for each combination of applied moments.

CONCLUSIONS

This study indicates that common valgus or varus braces leave the total compressive knee load unaffected during normal gait whereas muscle compensation in the sagittal plane has a much stronger influence on the total knee load. The results can be used as a guide for improving current knee braces on the market to ensure an efficient joint load reduction during gait.

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