REASONS FOR OSTEOPENIA IN ABOVE THE KNEE AMPUTEES: A BIOMECHANICAL EXPLANATION

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Introduction

Studies undertaken over the past 50 years have shown that above the knee amputees (AKAs) lose bone mass at rates of postmenopausal individuals. It has been established that load bearing physical activity is a major promoter of bone health. While therapeutic physical activities have helped improve bone health of returning space travellers [1], AKAs bone loss continues despite physical activity and disregarding significant differentiators such as age [2, 3]. This loss of bone mass results in a higher rate of femoral fractures in conjunction with the fact that AKAs are more likely to fall in comparison to able bodied individuals. It has been established that skeletal load bearing is a major promoter of bone health. Therefore, in this study we considered the mechanical environment furnished by prosthetic design and techniques, which permit AKAs high mobility levels and participation in sports.

We employ numerical simulation aimed to describe the mechanical environment and the interplay of prosthetics, skeletal and soft tissue system to explain osteopenia in above knee amputees.

Methods

A series of FE models were developed using skeletal geometries of the pelvis and the femur from a CT scan. Most previous studies on AKAs have limited their models to the femur. The hip joint was manipulated in frontal plane at 15° adduction with collated sagittal at 10° extension, 0° (neutral), 10° flexion and 20° flexion. A 3D scanned ischial containment socket (ICS) was fitted to the skeletal geometries, and body weight (BW) loading imposed from the total body centre of mass totalling 100% to 225% in 25% increments, as load bearing experienced by an individual weighting 100 kg representing loads experienced during walking or running. Finally, soft tissue compressibility between the ischium and the ICS was controlled allowing either: 5mm, 2.5mm and 0mm.

A second series of FE models for comparison were created following previous description substituting the socket design from ICS to SubIschial, the former is extensively prescribed while the latter is a novel and much more expensive technique.

Results

Proximal trabecular bone in a residual limb wearing an ICS, showed stunted levels of strain energy density

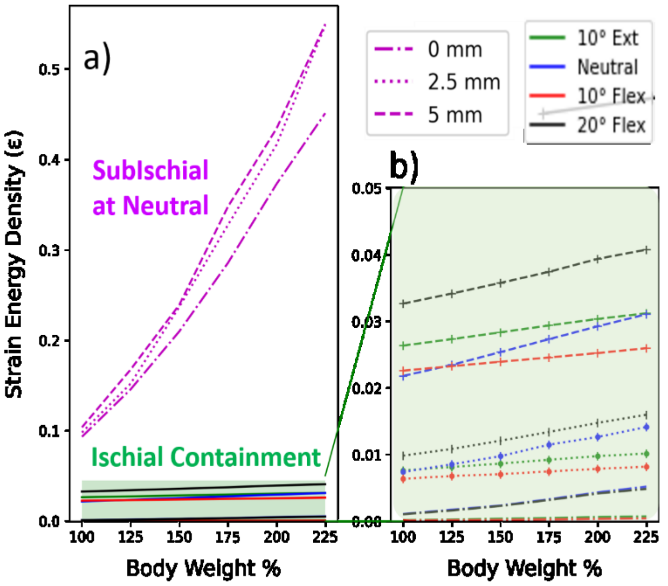

Figure 1: a) Strain energy density for ICS and in a SubIschial socket at neutral hip joint alignment b) Zoom-in behaviour of stimulation under an ischial containment socket for hip joint variations and soft tissue compressibility.

(SED) in comparison to the SubIschial case (Fig 1a). For the ICS hip joint alignment at 20° of hip flexion consistently showed the highest levels in SED stimulation, trend amplified by higher amount of compressive soft tissue as mortar (Fig 1(b)).

Discussion

Our results show that intimate ischium capture, a technique employed for ischial containment sockets for comfort and as a mobility promoter, results significant reduction in the mechanical stimulation of the bone in comparison to the SubIschial socket. As this study is limited to numerical further research is needed to confirm our findings using *in vivo* data capture. To our knowledge, these models are the first ever that explain the mechanical effect of prosthetic techniques on bone loss in above the knee amputees.

References

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