Associations between Walking Speed and Limb Loading Characteristics on Cartilage Structure and Strains in those with Traumatic Lower-Limb Amputation

Steven A. Garcia[1], Nikou Nikoumanesh[1], Shraddha Sudhir[1], Kharma Foucher[1], Lindsay Hannigan [1]

[2] Department of Rehabilitation Sciences, University of Illinois Chicago; Chicago, IL, USA
Email: stevenag@uic.edu

Summary

Overreliance on the intact limb after lower-limb amputation (LLA) is thought to lead to knee osteoarthritis (OA). Here we utilized ultrasound imaging and gait analysis to probe gait indicators of intact knee health after LLA. We observed faster walking speeds (and potentially larger GRFs) were linked with thicker femoral cartilage. Interestingly, we did not observe excessive intact limb GRFs relative to the amputated limb in our group of LLA. Future work needs to confirm if the contributors to knee OA risk after LLA are mainly attributed to overloading, poor mobility or a combination of factors.

Introduction

Individuals with LLA are at high risk for intact knee OA development – classically attributed to overreliance on the intact limb for support and mobility [1]. Yet surprisingly few data have linked gait mechanics with direct imaging of intact knee health prior to OA onset after LLA. Thus, modifiable risk factors impacting intact knee OA trajectories are unclear. Ultrasound (US) is a low-cost, valid imaging tool to assess cartilage thickness and mechanical function (via strain assessments). Given gait compensations after LLA include excessive intact limb loads and slower walk speeds relative to able bodied controls [2], these gait metrics may be linked with cartilage health after LLA. Here, we evaluated associations between intact limb vertical GRFs, preferred walk speed, and femoral cartilage thickness and strains in those with LLA.

Methods

Ten persons with traumatic LLA (Sex:6M-4F, Age:50.3±15.8 yrs, BMI: 27.1±5.9) completed treadmill gait assessments and femoral cartilage US. Vertical GRFs during treadmill walking at self-selected (SS) speed were sampled at 1000Hz and filtered at 12Hz. Force metrics included the 1st and 2nd peak vertical GRF and minimum vertical GRF during midstance. Femoral cartilage US images were captured in the intact limb in max knee flexion at two sites using standard parameters (Figure 1: 12MHz, depth=3cm). Prior to baseline images, participants rested supine for 30 minutes to allow for cartilage thickness normalization. Three US images at each site were captured before and after a 15-minute walk at SS speeds to evaluate cartilage mechanical function (i.e., strain). Cartilage thickness was calculated using an open-source MATLAB program as the Euclidean distance between superficial and deep cartilage interfaces at each pixel across the entire ROI (in mm). Cartilage strain was defined as percent Δ from pre-to-post-walking. Pearsons *r* were used to evaluate correlations between GRFs, walk speed and cartilage outcomes (α=0.05). Paired t-tests were used to compare GRFs between intact and amputated limbs for supplemental analysis (α=0.05).

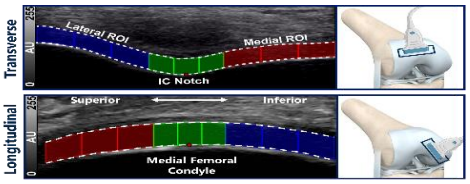

Figure 1: US Images Sites for Femoral Cartilage. Transverse ROI: Trochlea. Longitudinal ROI = Medial Femoral Cartilage (MFC).

Results and Discussion

We observed moderate-strong correlations between SS speeds and resting MFC thickness in central (r=0.68, p= 0.046) and distal (r=0.80, p=0.01) ROIs. Walking speed was not correlated with resting trochlear thickness or cartilage strains in any ROIs (p>0.32). Larger 2nd peak vertical GRF was moderately correlated (r=0.61) with thicker resting MFC thickness but only trended towards significance (p=0.08). Lastly, GRFs were not different between limbs (p>0.17) suggesting those with LLA did not tend to favor the intact limb for support during gait.

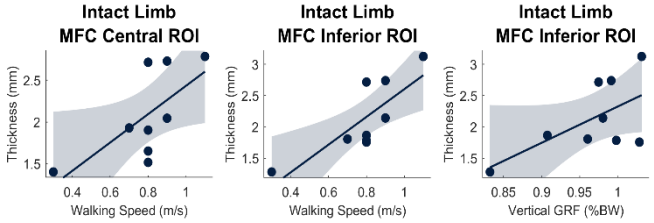

Figure 2: Scatterplots for relevant associations with cartilage ROIs.

Faster habitual walking speeds were associated with thicker intact limb MFC cartilage which may suggest more functionally mobile individuals exhibit healthier cartilage. While it trended towards significance, larger 2nd peak GRFs were also moderately associated with thicker cartilage. Higher walking speeds, and GRFs have been previously associated with favorable cartilage outcomes in those with ACLR and are related to reduced risk of OA progression [3]. While our results represent a small sample, future work is needed to evaluate more joint-specific measures and their associations with joint health after LLA to inform population.

Conclusions

Faster walking speeds are linked with thicker femoral after LLA. Future work should evaluate how mobility and limb loading impacts OA trajectories after LLA.

References

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