O4 KNEE BIOMECHANICS AND REHABILITATION I

O4.1 Shape analysis of inter-joint motion coupling patterns in a stair-descent task following ACL reconstruction captures asymmetries in coordination up to two years post-surgery relative to non-injured controls

Dario Liebermann[1], Jonas Markström[2], Jonas Selling[2], Charlotte Häger[2]
[1]Tel-Aviv University, [2]Umeå University

BACKGROUND: This study focused on the functional coupling between lower-limb joints during a stair-descent task after anterior cruciate ligament (ACL) repair. Surgery may improve knee stability although motor control mediated by sensory feedback (e.g., proprioceptive) may remain impaired. It is not clear if, when and how normal knee function is restored, and whether restoration can be attributed to compensations in other joints rather than to recovery. We assumed that lower-limb control involves coordination and studied spatiotemporal patterns within and between joints. We hypothesized that global patterns of spatial symmetry among the injured and non-injured legs would be an expression of impaired joint coordination post-surgery that would improve given enough time. We also hypothesized that global temporal features would remain invariant (isochrony principle) but the intrinsic temporal structure in the stair-descent would change.

Methods: Data were obtained from 3D marker data recordings (12 stair-descent trials, 6 per leg) to capture alterations in joint kinematics following knee surgery. Inter-joint coupling was determined in unilateral ACL-injured persons (N=32) who underwent reconstruction and were tested either at >1 (Early; N=11), >10 (Mid-term; N=11) and >29mo up to 129mo post-surgery (Late; N=10). Subgroups were compared with each other and with healthy-knee Controls (N=24). Symmetry among legs was estimated using a dissimilarity index (DI) derived from Generalized Procrustes Analyses applied on superimposed average shapes of bilateral two-joints (knee-hip and knee-ankle) and three-joint (hip-knee-ankle) angular displacement-time plots (sagittal plane). One-way ANOVAs and t-tests were used to compare 'Subgroups' and 'Legs' in terms of kinematic features ($p<0.05$).

Results: ANOVA showed a significant effect of subgroup when using DI. The evidence suggests that asymmetric patterns of joint coupling remain up to ~2ys post-surgery, and that both legs approach similar patterns at longer times ($p=0.0018$). 'Early' and 'Mid' subgroups were not different from each other but both differed significantly from 'Late' and 'Controls' ($p<0.01$), which did not differ. Such effects remained undetected using intrinsic measures (e.g., the angular range of joint motion at different stages of the stair descent). Contrary to global spatial measures, global temporal measures were similar among subgroups (e.g., no differences in stance duration) while some measures within the stages of the stair descent changed (e.g., first double-support time).

Conclusions: Up to 10mo from ACL repair, compensation dominates function. Later in the recovery process (>2ys), joint coupling in both legs may share a common kinematic signature (i.e., symmetry) suggesting full recovery. Our results challenge too early return to sports. Further attention to between- and within-leg joint coupling, up to several years following ACL-injury, is warranted.