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A COMPUTATIONAL LOWER-EXTREMITY MODEL TO QUANTIFY THE STABILITY OF AN ANTERIOR CRUCIATE LIGAMENT DEFICIENT KNEE JOINT AT HEEL STRIKE: GAIT PARAMETERS MARKING COPERS FROM NON-COPERS

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Summary: Anterior cruciate ligament (ACL) is a primary ligament of the knee joint. Its rupture, as a common knee injury especially in younger population, results in the joint instability (subluxation, giving way) and subsequent compensatory actions leading to increased risk of re-injuries and degeneration. Unfortunately, ACL reconstruction surgery can neither insure return to pre-injury activities nor protect the joint against long-term degeneration. Nevertheless and unlike non-copers, a small portion of ACL deficient patients (copers) can with no reconstruction surgery continue with their pre-injury activities even with no episodes of instability. The underlying mechanisms in play for such distinct performances remain yet unknown. Here we investigated the stability of ACL-Deficient (ACL-D) knee joint at heel strike (HS) of gait using a computational hybrid musculoskeletal model of the lower extremity. Role of alterations in joint rotations-moments, posterior tibial slope (PTS), and muscle cocontraction, within their variations reported in the literature, on the joint stability (critical muscle stiffness coefficient (qcr) (as a surrogate of stability margin) as well as anterior tibial translation (ATT)) was investigated. Results demonstrated that small extension (and not flexion) moments which activate hamstrings more than quadriceps are necessary to maintain the stability of ACL-D joint at HS. Results showed that flexion rotations are also essential to increase the stability (smaller qcr and ATT) of the ACL-D joint. With flexion rotations >5 deg, knee joint stability substantially improved to levels similar to the intact knee. Reduced PTS acted on the joint stability exactly in line with higher flexion angles. Low cocontraction levels of 1-3% (in hamstrings and quads and not in gastrocnemii) could also improve the stability of the ACL-D joint in flexion angles > 3 deg. Overall, to maintain the stability of ACL-D joint at the pre-injury intact levels (i.e., ATT <3mm and qcr <20-30), presence of small extension moments and higher flexion angles (>5 deg) or lower PTS are required at HS. These act as markers to differentiate copers from non-copers.
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