Effect of Load on Three-dimensional Patellar Kinematics
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Introduction: Three-dimensional patellar kinematics can be assessed in vivo using magnetic resonance imaging (MRI) based methods. Most often, closed-bore MRI scanners are used; therefore, kinematics are assessed with the subject in a supine position. To attempt to simulate physiological loading, axial(1,2) or torsional(3) loads are often applied through the knee, and these applied loads typically must be much lower than those experienced during daily activities. The effect of the magnitude of applied load on patellar kinematics has not been studied to date. The aim of this study was to determine the effect of load magnitude on three-dimensional patellar kinematics in a closed-bore MRI scanner.

Materials and Methods: We assessed three-dimensional patellar kinematics (flexion, spin and tilt; proximal, lateral and anterior translation) in 11 healthy subjects (4F, 7M, age 34.6 ± 6.3 yrs), using a validated, quasi-static, MRI-based method (1,4). Kinematics were assessed at six flexion angles between approximately 0° and 45°. At each angle, subjects loaded the knee by pressing against a pedal to loads of 0% (no load), 15% and 30% bodyweight (BW) using a custom designed loading rig. A one-way repeated measures ANOVA with Bonferroni correction for multiple comparisons was used to assess the difference between the 3 loading levels (α=0.0083). In situations where a statistically significant difference was observed, a Holm t-test was used to isolate the differences between the load levels (α=0.0028 to account for multiple comparisons).

Results: The patella was in a more extended position with increasing load (ANOVA p<0.001)(Figure 1) and the differences were statistically significant for all three comparisons using the Holm t-test (between 0% and 15% (p<0.001), 0% and 30% (p<0.001), and 15% and 30% (p<0.001)). The patella tilted medially with increasing load (ANOVA p<0.001)(Figures 1 and 2); these differences were significant between the 0% and 30% (p<0.001), and 15% and 30% (p<0.001)) loading levels using the Holm t-test. The patella was positioned more proximally with increasing load (ANOVA p<0.001)(Figure 3); these differences were statistically significant between the 0% and 30% (p<0.001), and 15% and 30% (p<0.001) loading levels using the Holm t-test. The ANOVA results for spin and lateral and anterior translation were not statistically significant (p=0.066, 0.096 and 0.985, respectively).

Discussion: The results suggest that loading the knee changes some patellar kinematics parameters (flexion and tilt; proximal translation) but not others (spin; lateral and anterior translation). The results for flexion and proximal translation are not surprising because the patella is likely pulled proximally as the quadriceps muscle contracts when the load is applied. Further, when a greater load is applied, the lateral force component acting on the patella will also increase which may explain the increase in medial patellar tilt with increasing load. The finding for patellar tilt is consistent with a previous study of two-dimensional patellar kinematics that reported differences between the unloaded condition and a dynamic assessment(5), although our differences with the static loaded condition were not as pronounced. Although our observed differences were small, previous work has shown that small differences in kinematics are associated with patellofemoral pain syndrome(6). A limitation of this work is that kinematics were not assessed in full weightbearing. Differences between no load and physiologic weightbearing are likely larger than the differences found in the current study. We conclude that studies of patellar kinematics done with little or no applied load may not accurately reflect kinematics at physiological load levels, and may provide different results to those acquired in weightbearing.