PRESENTING AUTHOR'S NAME & RESEARCH TITLE

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Biomechanical Analysis of Knee Motion to Prevent and Treat Progression of Knee Osteoarthritis

PURPOSE/BACKGROUND

Knee joint instability, or sudden loss of postural control during weight-bearing activities, is a distinct mechanical impairment reported by a majority of knee osteoarthritis (OA) individuals. This pathology is reportedly related to the OA development and accelerated progression, and presents as large and/or abrupt - jerky - knee motions during activities of daily living. Although directly implicated in OA pathogenesis and a mechanical parameter that researchers may easily quantify with biomechanical analysis, no objective kinematic measure of knee instability currently exists**.** Thus, the purpose of this work was to fill that critical void and provide an effective measure of knee instability. We hypothesized that knee joint instability, or "jerky" frontal plane motion, will increase with the progression of knee musculoskeletal injury and disease, and the demand of activities of daily living; thereby, effectively quantify knee joint instability.

MATERIALS & METHODS

To date, 17 participants from three cohorts (1: adults with ACL reconstruction, 2: adults with radiographically confirmed knee OA, and 3: sex matched controls) participated. Each participant had knee biomechanics quantified during a 10 m over-ground walk performed at 1.3 m/s and self-selected speed over flat and uneven surfaces. Each participant performed three successful walk trials for condition. During each trial, participants had 3D lower limb biomechanical data recorded using ten high-speed (240 Hz) optical cameras (Vantage, Vicon Motion Systems, LTD, Oxford, UK). Then, filtered marker trajectories were processed to obtain 3D knee joint rotations using Visual 3D (C-Motion, Rockville, MD), and jerk cost of frontal plane knee motion was calculated for the affected (or dominant) limb, as follows:

$$\text{Jerk Cost} = \frac{1}{2}\int_0^{t_f}\left(\frac{\Delta^3\theta}{\Delta t^3}\right)^2 dt$$; where: θ is knee angle (rad) and t is time (sec);

For statistical analysis, jerk cost of frontal plane knee during weight acceptance (0–16 % of stance), mid-stance (17–50% of stance) and full stance (0-100 % of stance) were submitted to a three-way RM ANOVA to test main effects and interactions between cohort (ACL-R, OA and control), surface (normal and uneven) and speed (1.3 m/s and self-selected). Alpha level was $p < 0.05$.

RESULTS

Although OA participants exhibited up to 95% and 96% greater jerk cost of frontal plane knee motion than the control and ACL-R participants, there was no significant main effect of group ($p>0.349$). A main effect of surface for frontal plane knee motion during weight acceptance ($p=0.019$), mid-stance ($p=0.040$) and full stance ($p=0.038$) was observed. Contrary to our hypothesis, however, participants exhibited greater jerk of frontal plane knee motion on the normal compared to uneven surface during each phase of the gait cycle. Walk speed did not impact jerk cost of frontal plane knee motion ($p>0.061$), despite the fact participants exhibited a 20 % to 50 % reduction in jerk cost of frontal plane knee when walking at 1.3 m/s.

DISCUSSION/CONCLUSION

Considering jerk cost is purportedly related to joint loading and injury risk, the large, albeit statistically insignificant, increase in jerky frontal plane knee motion exhibited by the OA participants may place deleterious loads on the knee that damage the joint's articular surfaces, accelerating disease progression.