

# COMPARISON OF THREE DIMENSIONAL PATELLOFEMORAL JOINT REACTION FORCES IN PERSONS WITH AND WITHOUT PATELLOFEMORAL PAIN

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## INTRODUCTION

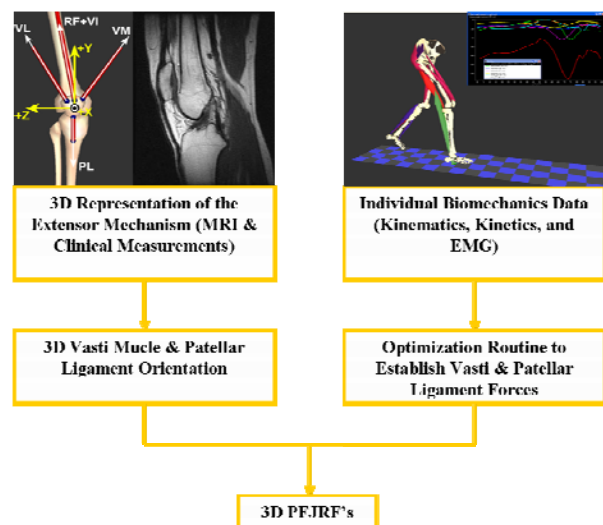
Patellofemoral pain (PFP) is one of the most common disorders affecting the lower extremity.<sup>1,2</sup> Although it is commonly assumed that PFP is the result of abnormal patellofemoral joint loading,<sup>3</sup> there is little evidence to support this premise. Using a subject specific three dimensional model, the purpose of this study was to determine if persons with PFP demonstrate differences in patellofemoral joint reaction forces (PFJRF) compared to pain-free controls.

## METHODS AND PROCEDURES

Twenty individuals with PFP and twenty pain-free controls were recruited for this study. All subjects underwent two phases of data collection: 1) MRI assessment of the knee, patellofemoral joint, and thigh, and 2) kinematic, kinetic and EMG analysis during walking (80 meters/min), running (200 meters/min) and ascending/descending stairs (50 steps/min).

An overview of the model is illustrated in Figure 1. Using data obtained from magnetic resonance imaging (MRI) and clinical measurements, a subject specific representation of the extensor mechanism was created using SIMM modeling software (MusculoGraphics, Santa Rosa, CA). Individual gait data were used to drive the model (via an optimization routine) and three dimensional vasti muscle forces and subsequent three dimensional PFJRF's were

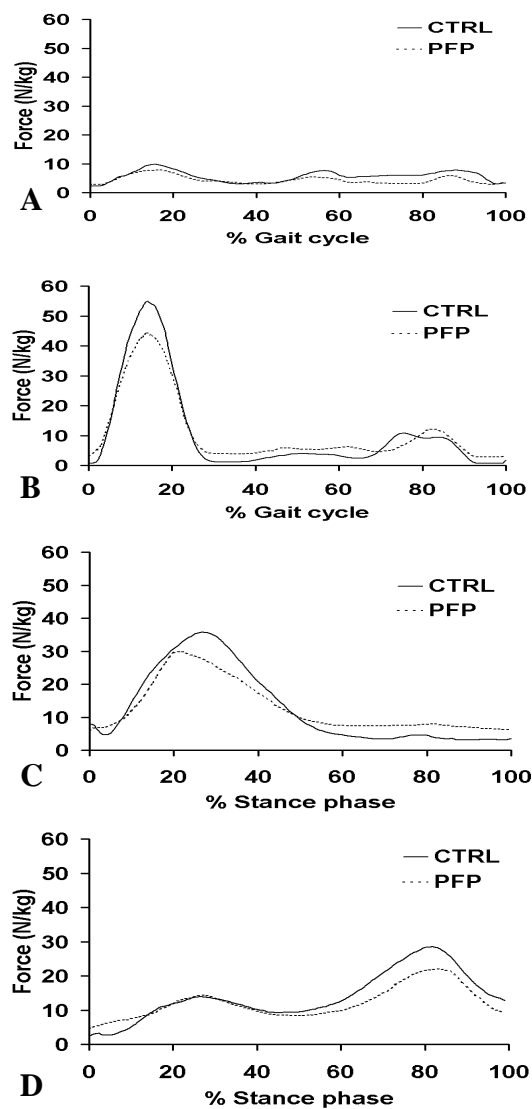
computed. The following subject specific input variables were used in the model: 1) three dimensional kinematics of the lower extremity, 2) net knee joint moment in the sagittal plane, 3) hamstring and gastrocnemius EMG, 4) extensor mechanism lever arm, 5) vasti muscle orientation, 6) vasti muscle physiological cross-sectional area proportions, 7) patella flexion angle, and 8) patella ligament orientation. Model outputs consisted of the resultant PFJRF as well as the posterior, superior and lateral components of the PFJRF. Comparisons of peak forces were made between groups across conditions using a 2-factor ANOVA. This analysis was repeated for the resultant PFJRF and each component of the PFJRF



**Figure 1.** Patellofemoral joint model used to estimate 3D patellofemoral joint reaction forces

## RESULTS

When averaged across all conditions, the PFP group demonstrated lower peak resultant PFJRF's compared to the control group (25.9 vs. 32.2 N/kg-bwt; Fig.2). Although similar decreases were observed in the PFP group for the peak posterior (24.2 vs. 30.5 N/kg-bwt) and superior (7.9 vs. 10.4 N/kg-bwt) components of the PFJRF, the PFP group had higher peak lateral forces compared to the control group across all conditions (5.0 vs. 2.2 N/kg-bwt).



**Figure 2.** Resultant PFJRF's during walking (A), running (B), ascend stairs (C), and descend stairs (D).

## DISCUSSION

When average across all conditions, the peak resultant PFJRF's were 20% lower in the PFP group. This finding is consistent with Heino et al. who reported a 22% and 33% decrease in peak PFJRF's in persons with PFP during walking and stair ascent respectively.<sup>4,5</sup> When the resultant PFJRF was broken down into its orthogonal components, the forces were always in the posterior, superior, and lateral directions. Despite the lower posterior and superior forces, the PFP individuals demonstrated higher peak lateral forces when compared to the control group. This finding was observed in three of the four tasks.

## SUMMARY

The lower resultant, posterior and superior forces observed in the PFP group support the premise that these individuals may be employing strategies to minimize patellofemoral joint forces (i.e. quadriceps avoidance). However, the higher lateral forces in the PFP group are consistent with clinical observations of lateral patella subluxation in this population.

## REFERENCES

1. Fulkerson JP. (2002). *Am J Phys Anthropol*, 30:447-456.
2. Malek M, and Mangine R. (1981). *J Orthop Sports Phys Ther*, 2:108-116.
3. Goodfellow J et al. (1976). *J Bone Joint Surg Br*, 58:291-9.
4. Heino Brechter J, and Powers CM. (2002). *Med Sci Sports Exerc*, 34:1582-93.
5. Brechter JH, and Powers CM. (2002). *Gait Posture*, 16:115-23.

## ACKNOWLEDGEMENTS

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