CONTINUOUS RELATIVE PHASE WITHIN THE LOWER EXTREMITY IN RUNNERS WITH PATELLOFEMORAL PAIN DURING A PROLONGED RUN

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INTRODUCTION

Patellofemoral pain (PFP) syndrome is the most common running related injury. However, little progress has been made in understanding the etiology of PFP. Recent literature suggests that the patellofemoral joint may be influenced by the coupling of the segments that are both distal and proximal to the knee (Tiberio 1987; Powers, 2003). One way to assess joint coupling is through the measurement of the continuous relative phase (CRP). The CRP is a continuous measure of coordination between two oscillatory components, such as rearfoot eversion/inversion and tibial rotation (Hamill et al, 1999). A CRP of 0° corresponds to in-phase coupling, meaning the phase angles for the two motions are identical, and a potentially stable coupling pattern exists as they are behaving similarly. As the CRP moves away from 0° in either a positive or negative direction, the two motions become more out-of-phase and are behaving in a less similar fashion.

The knee pain experienced by runners with PFP is generally not present at the beginning of a run. Instead, the onset is subtle and progressively worsens throughout the run. Yet no studies have examined joint coupling in runners with PFP at the end of a prolonged run, where pain is likely to be present. Therefore, the purpose of this study was to investigate lower extremity CRP in runners with PFP over the course of a prolonged run. It was hypothesized that the PFP group would exhibit more out-of-phase CRP coupling across stance when compared to controls. In addition, it was expected that the PFP group would become out-of-phase to a greater extent than the controls at the end of the run.

METHODS

Twenty runners with PFP and 20 uninjured runners participated in the study. All were between the ages of 18 and 45 and ran at least 10 miles per week. All subjects performed a prolonged run on a treadmill at a self-selected pace. 3D kinematic data (120 Hz) of the leg with the most painful knee (random for controls) were collected for 20 footfalls at the beginning and at the end. The prolonged run ended when one of three events occurred: 1) 85% heart rate maximum was reached, 2) 17 was reached on the rating of perceived exertion scale, and 3) for the PFP group, 7 was reached on a visual analog pain scale.

The CRP relationships of interest included: 1) rearfoot eversion/inversion and tibial internal/external rotation (RF_{ev/in}-T_{rot}), 2) RF_{ev/in} and knee flexion/extension (RF_{ev/in}-K_{f/e}), and 3) RF_{ev/in} and knee internal/external rotation (RF_{ev/in}-K_{rot}). For each joint motion, the angles and velocities during stance were used to construct a phase plot (Hamill et al, 1999). The phase plot was normalized and phase angles were calculated. The CRP was then calculated from the two joint motions (i.e. RF_{ev/in}-T_{rot}) as the difference between each phase angle throughout stance. The CRP
was assessed over four periods that were based on vertical ground reaction force events. A two-factor ANOVA for each period of stance (group by time) was used to assess the CRP with a Tukey post-hoc for follow-up comparisons. Alpha was set at 0.05 and trends were identified for p values between 0.05 and 0.10.

RESULTS AND DISCUSSION

No interactions were detected for any of the CRP relationships, suggesting that both groups exhibited similar changes in CRP coupling over time (Figure 1). For the main effect of group, the PFP group was more out-of-phase during periods 1 and 2, where loading forces on the leg occur, for \( RF_{(ev/in)}-T_{(rot)} \) and \( RF_{(ev/in)}-K_{(f/e)} \) (Figure 1). This may have been related to a prolonged eversion difference that was observed in the PFP group. However, more in-phase coupling was found for \( RF_{(ev/in)}-K_{(rot)} \) during periods 1 and 2. This may have been a result of an observed earlier peak knee internal rotation in the PFP group, which would be related to motion of the femur. Since the femur articulates with both the patella and the tibia, these atypical CRP coupling patterns may have resulted in abnormal patellofemoral contact pressure. For the main effect of time, decreases in the CRP occurred during periods 1 and 2 at the end of the run (Figure 1). This resulted in downward shifts of the CRP curves in both groups. Interestingly, the CRP patterns in the PFP group at the end of the run resembled those of the uninjured group at the beginning of the run. The PFP group may have changed their coupling patterns in order to reproduce those associated with uninjured runners in a pain-free and non-exerted state. While this compensatory strategy did not reduce pain at the end of the run, it may have been successful in slowing the progression of the pain throughout the run.

SUMMARY/CONCLUSIONS

These findings demonstrate that runners with PFP display atypical CRP coupling patterns throughout the entire lower extremity when compared to uninjured runners during a prolonged run. These differences were primarily observed during the first half of stance and may have been adopted to slow knee pain progression.

REFERENCES