The Effect of Running Cadence Manipulation on Single-Step and Cumulative Knee Loading

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Summary

High cadence running reduces single-step and cumulative patellofemoral loading. Regardless of cadence condition, there was a small increase in PFJF and PFJS during each run. These results indicate that cadence manipulation may be useful for reducing knee loading during running.

Introduction

Patellofemoral Pain is the most common running-related musculoskeletal injury [1] and is linked to repetitive loading [2]. Increasing running cadence reduces single-step patellofemoral joint force (PFJF) and stress (PFJS) but increases the number of steps for a given distance. It is unclear if a reduction in single-step loading contributes to a decrease in cumulative knee loading during a running bout. It is also unclear if single-step loading changes throughout a running bout. We hypothesized that single-step loading would be lower during high cadence running but that there would be no difference in cumulative loading, and that single-step loading would increase during high cadence running only.

Methods

16 runners participated (7 females and 9 males; Height=1.73±0.07m, Mass=66.7±8.3kg, Age=21.5±3.7years, Self-selected Running Speed=3.34±0.4m/s, Weekly Running Amount=51.9±25.7km). Participants were excluded for any injury in the last 6 months, and for previous lower limb surgeries. Participants underwent a running biomechanics evaluation on a force- instrumented treadmill at their self-selected running pace while outfitted with retroreflective motion capture markers and laboratory-standard running shoes. During a screening visit, kinematic and kinetic data were sampled for 10 seconds at the end of each minute during a 5-minute run to determine habitual cadence. The second and third visits involved cadence manipulation trials in a counterbalanced order. These sessions involved 30 minutes of continuous running at the participant's self-selected speed, either at participants' habitual cadence (Mean=162 steps/min; 4881 steps) or with a cadence increased by 10% (Mean=176 steps/min; 5299 steps), both guided by a metronome. Kinematic (240Hz) and kinetic (2400Hz) data were sampled for 10 seconds every 5 minutes. Single-step PFJS and PFJF were calculated using a musculoskeletal model that uses an inverse-dynamics approach accounting for hamstring and gastrocnemius co-contraction [3]. Cumulative outcomes were estimated via the product of the total number of steps and average peak PFJF and PFJS during each running condition. Single-step and cumulative PFJF and PFJS were compared using independent samples t-tests, and PFJF and PFJS at each time point were further compared using a 2 (condition) by 5 (time) repeated measures ANOVA (α=0.05).

Results and Discussion

Single-step PFJF was lower during high compared to habitual cadence running (2359.9 (611) vs. 2946 (789) N, p=0.003, d=0.87). Single-step PFJS was lower during high compared to habitual cadence running (10.04 (2.49) vs. 12.22 (3.16) MPa, p=0.004, d=0.84). Cumulative PFJF was lower during high compared to habitual cadence running (12468683 (3169805) vs. 14297658 (3169805) N, p=0.040, d=0.56). Cumulative PFJS was not different between conditions (53049 (12934) vs. 59352 (13754) MPa, p=0.062, d=0.50).

The condition x time interaction effect was not significant (p=0.164). However, there were main effects of condition (p=0.003) and time (p=0.002) on PFJF and PFJS. Post hoc analyses indicated that PFJF was higher at 25 minutes of running (2707 N) compared with at 5 (2606 N, p=0.010), 10 (2644 N, p=0.010) and 15 minutes of running (2636 N, p<0.001). Post hoc analysis indicated that PFJS was higher at 25 minutes of running (11.342 MPa) compared with at 5 (10.956 MPa, p=0.009), 10 (11.095 MPa, p=0.006), and 15 minutes of running (11.067 MPa, p<0.001).

Conclusions

High cadence running reduced single-step PFJF and PFJS consistent with previous research, potentially redistributing demand to other joints. Despite an increase in the number of steps taken during the 30 minute run, cumulative PFJF remained lower during the high cadence condition. Small increases in PFJF and PFJS over time consistent across conditions may indicate exertion-induced changes in gait mechanics that could contribute to higher joint loading, particularly in the later stages of a run. These results indicate that cadence manipulation may reduce knee loading during running, but future studies are needed to examine how high cadence running affects loading at other joints and structures.

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