

Effect of Running-induced Fatigue on Patellofemoral Joint Loading Between Novice and Experienced Runners

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Summary

Long-term high stress on the patellofemoral joint during running is one of the causes of patellofemoral joint pain syndrome (PFPS). This study used a Vicon infrared motion capture system and a 3D force platform to quantify the biomechanical parameters of the patellofemoral joint during running before and after fatigue. The results showed that both novice and experienced runners exhibited a significant increase in patellofemoral joint contact force after fatigue compared to before fatigue. In contrast, no significant change was observed in patellofemoral joint stress. The study results indicated that, whether for novice or experienced runners, continuing to run after fatigue increased the load on the patellofemoral joint, thereby elevating the risk of injury.

Introduction

Knee pain remains the most common running injury. A survey by Taunton et al. [1] found that overuse injuries, particularly PFPS, had the highest incidence rate at 16.5%. The mechanism of overuse injuries is the cumulative effect of repeated high-load stress on muscles and bones [2]. Therefore, changes in patellofemoral contact force and patellofemoral joint stress during running may contribute to the incidence of PFPS. While previous studies have mainly focused on general runners, little is known about the differences between novice and experienced runners regarding their patellofemoral joint biomechanics, especially under fatigue conditions. Therefore, this study aimed to investigate the biomechanical characteristics of the patellofemoral joint in novice and experienced runners before and after fatigue during running.

Methods

Thirty healthy male runners aged 18-26 years (15 novices and 15 experienced runners) were recruited. Participants were asked to run on a treadmill with the speed increasing by 1 km/h every 2 minutes until reaching Borg scale level 13, then maintained that speed until reaching Borg scale level 17, 90% of maximum heart rate, and maximum oxygen uptake, at which point the participants were considered to have reached a state of fatigue and stopped running after 2 minutes. Before and after fatigue, a Vicon infrared motion capture system and a 3D force platform (AMTI, Watertown, Massachusetts, USA) were used to synchronously collect lower limb kinematics and ground reaction force data at a frequency of 1000 Hz [3] at a running speed of 12 km/h ($\pm 5\%$). Relevant parameters were calculated using inverse dynamics and a patellofemoral joint force model. A two-way repeated measures ANOVA was used for analysis and comparison, with a significance level set at $p < 0.05$.

Results and Discussion

The results showed that there were no significant interaction effects among the maximum knee flexion angle, quadriceps force, patellofemoral joint stress, and patellofemoral contact area ($p > 0.05$). However, a significant main effect of time was observed for the patellofemoral joint contact force ($P = 0.026$, **Figure 1**). Specifically, after fatigue, the patellofemoral joint contact force in novice runners increased from 6.70 ± 1.57 BW to 7.12 ± 1.78 BW, while in experienced runners, it rose from 6.41 ± 1.90 BW to 6.88 ± 2.06 BW.

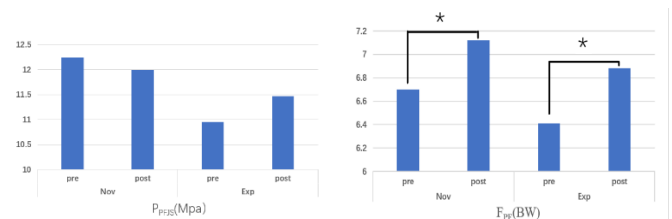


Figure 1 Patellofemoral joint stress (P_{FJIS}, left) and patellofemoral joint contact force (F_{PF}, right) of novice runners and experienced runners before and after fatigue. *Significant main effect of time, $p < 0.05$.

Conclusions

The findings of this study indicated that both novice and experienced runners showed a significant increase in patellofemoral joint contact force after fatigue compared to before fatigue. This suggested that continuing to run in a fatigued state intensified the load on the patellofemoral joint, thereby increasing the risk of injury. Therefore, runners should adopt appropriate preventive measures to reduce the occurrence of PFPS.

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