Knee Joint Loading During Cycling: Should Osteoarthritis Patients Pedal with High or Low Cadence?

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Summary

This study examines the effects of cadence and power on knee joint loading in cyclists with knee osteoarthritis (KOA). It was found that higher cadences and lower powers reduce all examined parameters of knee loading. Results suggest KOA patients should avoid low cadences and high powers to minimize knee strain.

Introduction

Low-impact sports such as cycling are one of the most recommended conservative treatments for knee osteoarthritis (KOA) [1], yet the knee loading of sportive cycling has not been adequately studied. The external knee adduction moment (KAM), its peak (KAM_{peak}) [2], and its impulse (KAM_{imp}) [3] are the most important predictors of the progression of KOA. More recently, it has been shown that the cumulative knee loading (CKL, the KAM_{imp} extrapolated to a time period of interest) can differentiate between healthy and osteoarthritic knees and thus estimate the loading dose [4]. This study aims to investigate the influence of cadence and power during sportive cycling on the three knee load parameters KAM_{peak}, KAM_{imp}, and CKL.

Methods

Twelve male active cyclists with diagnosed KOA (age: 57.3 ± 7.9 years; height: 1.84 ± 0.06 m, weight: 87.67 ± 11.17 kg; BMI: 25.7 ± 2.9; KL-score 2-4) participated in this study. They cycled at cadences of 60, 80, and 100 rpm and with power outputs of 157, 210, and 261 W on an SRM ergometer [SRM GmbH, Jülich, Germany]. Lower body kinematics (16-camera motion capture system, Qualisys AB, Gothenburg, Sweden) and 3D pedal reaction forces (custom-made instrumented cycling pedals [5]) were used to determine knee joint moments with scaled inverse-dynamic OpenSim models [6]. KAM_{imp} was calculated by time-integrating KAM for each cycle and then averaging the cycles. Subsequently, KAM_{imp} was extrapolated to one hour using individual cadences to obtain CKL. After time normalization to 360 frames the KAM was averaged to determine the KAM_{peak} of each test subject. Separate repeated measures ANOVAs and subsequent post-hoc tests were performed for KAM_{peak}, KAM_{imp}, and CKL.

Results and Discussion

Repeated measures ANOVA revealed significant main effects for cadence and power ($p<0.001$) as well as significant interaction effects ($p<0.001$) in all parameters. The main effects had large effect sizes ($\omega^2>0.14$). The interaction effects showed small to medium effect sizes ($\omega^2=0.011$ to 0.077). Post-hoc tests showed significantly lower values for higher cadences in all parameters (Figure 1). The only exceptions were KAM_{peak} at 157 W and 210 W between 60 and 80 rpm.

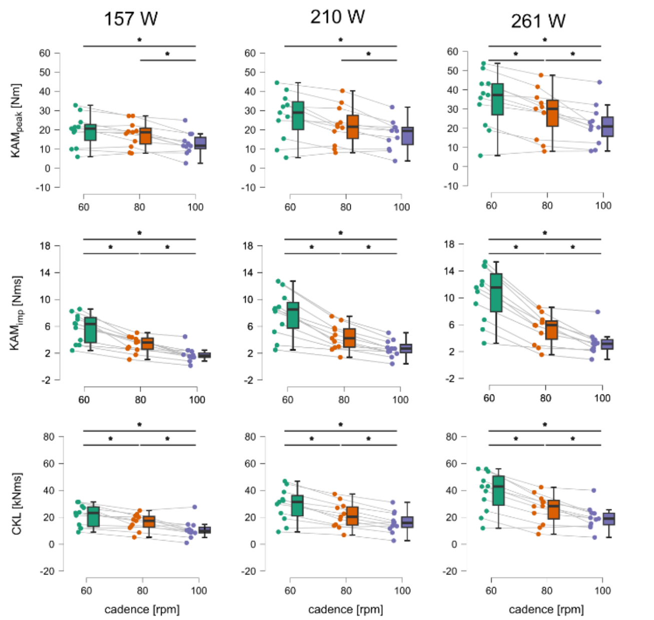

Figure 1: Knee loading parameters KAM_{peak}, KAM_{imp} and CKL for all power (157, 210, and 261 W) and all cadence (60, 80, and 100 rpm) conditions. Asterisks indicate $p < 0.05$.

The analysis suggests that KOA patients should avoid high power outputs and low cadences to reduce knee loading. Particularly, when accelerating after corners and traffic lights or when riding uphill, KOA patients should choose low gears. These findings contrast with Fang et al [7], who could not detect cadence influences on KAM_{peak}. One explanation for these divergent results could be that subjects cycled at lower power outputs, but a direct comparison is difficult as the workload was reported in kg.

Conclusions

All knee loading parameters (KAM_{peak}, KAM_{imp}, and CKL) were reduced with higher cadences. It can be concluded that KOA patients should avoid high powers and low cadences to reduce knee loading.

References

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