The Effects of Anatomical and Sex Differences on Knee Joint Loading in Cycling

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Summary

This study examines the effects of relative pelvic width, valgus knee angle and sex on knee joint loading in cyclists. The combined parameters did not explain the external knee adduction moment (KAM).

Introduction

Understanding sex- and anatomy-specific differences in musculoskeletal biomechanics is essential for accurately assessing joint health and developing effective interventions. The external knee adduction moment (KAM) strongly predicts medial compartment loading in the knee joint, with a relation to the onset, severity, and progression of knee osteoarthritis (OA) [1]. But also sex differences influence the risk and progression of OA. The female pelvis is broader relative to body size. This broader pelvis shifts the hip joints laterally, increasing the valgus angle at the knee and altering load distribution [2]. These structural differences emphasize the need for sex-specific clinical approaches. This study examines whether these anatomical differences lead to sex - specific variations in KAM, with a broader female pelvis potentially increasing knee valgus and altering load distribution.

Methods

Six female and seven male healthy, active cyclists (31,5 ± 13,5 years; 180,77 ± 9,51 cm, 75,2 ± 9,9 kg; BMI: 23,0 ± 1,9) participated in this study. They cycled at cadences of 60, 80 and 100 rpm with power outputs of 157, 210 and 261 W on an 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 [3]) were used to determine knee joint moments with a scaled inverse-dynamic OpenSim model [4]. Peak KAM values per rotation were averaged for each subject to determine KAM_{peak}. The effects of relative pelvic width, knee valgus, and sex on KAM_{peak} were assessed through a linear regression. The data processing was performed using custom Matlab code and JASP was used for all statistical calculations.

Results and Discussion

The statistical analysis showed p-values above 0.05 for all conditions, indicating no significant effect on KAM_{peak} (Figure 1). Possible reasons include the small sample size of 13 cyclists, limiting statistical power, and insignificant pelvic width differences between the sexes (Table 1). Additionally, anatomy may only play a minor role in knee loading, while movement strategy is likely the key factor. Further investigation is needed through a detailed analysis of KAM_{peak} components, including pedal reaction force and moment arm.

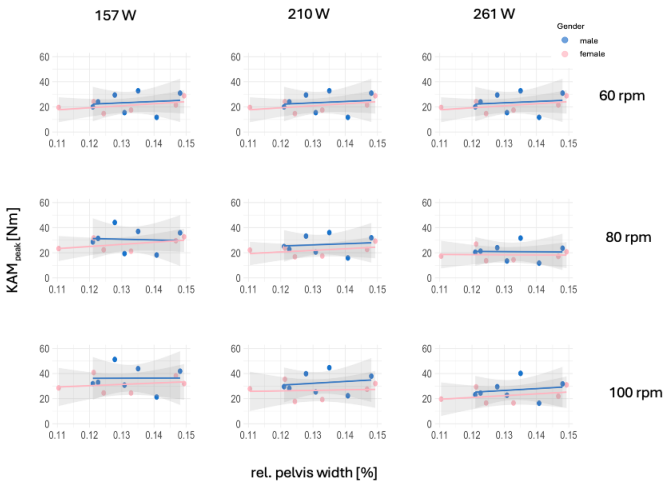

Figure 1: KAM_{peak} for all power (157, 210, and 261 W) and all cadence (60, 80, and 100 rpm) conditions for male and female.

Conclusions

Although preliminary, we could not assess an effect of relative pelvic width, valgus knee angle, or sex on KAM_{peak} in cyclists. Based on these results we assume that knee joint loading is more influenced by movement strategy than by anatomical differences.

References

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[2] Fulkerson J. (1997) *Disorders of the Patellofemoral Joint*; Williams & Wilkins
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Table 1: Mean and standard deviation for height, age, pelvis width, relative pelvis width and knee valgus angle.

Sex	Height [cm]	Age	Pelvis width [cm]	Rel. pelvis width [%]	Valgus angle (°)
Male	186,57±8,94	33,0±15,9	24,7±2,3	0,13±0,01	3,25±2,72
Female	174,00±4,38	29,7±11,3	22,8±2,8	0,13±0,02	2,71±1,60