BOOK OF ABSTRACTS Open Access

Bike fitting: finding an optimum between performance and overuse injuries prevention? Influence of saddle fore-aft position on knee joint forces

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Abstract

Background: The Union Cyclist International (UCI) regulates saddle setback - *'the tip of the saddle shall be a minimum of 5 cm to the rear of a vertical plane passing through the crank axis but no maximum is recommended'* - while there is no scientific rational supporting this regulation. Furthermore, the absolute value of 5 cm applies to all cyclists without accounting for cyclist's anthropometry and, in other disciplines such as track cycling and triathlon that are not subject to this regulation, a smaller setback is often used while there is no higher prevalence of joint overuse injuries.

Purpose: The aim of this study was to investigate the effect of saddle setback on knee joint forces exhibited during cycling. A musculoskeletal modelling approach was developed and, in an attempt to identify the underlined mechanisms responsible for knee joint forces, pedal force, knee kinematics and knee muscle forces were investigated

Methods: Ten well-trained (8.5 ± 6.75 years of experience in competition and average weekly training volume 4.0 ± 0.8 hours) cyclists volunteered to participate in the study. A stationary cycle ergometer was instrumented with two six-load component force sensors that were integrated in the pedals. A 20-camera motion analysis system was used to acquire 3D kinematics. Markers data and pedal forces served as input of the model for the computation of knee joint forces that resulted from the recommended Opensim calculation steps: 1) *scaling* to participant's anthropometry, 2) *inverse kinematics* to compute joint angles, 3) *static optimisation* to compute muscle forces and 4) *joint reaction analysis* to compute tibiofemoral forces and patellofemoral forces. Knee joint forces were normalised to pedalling cycle and the mean and peak of the 3 components of each forces were calculated. Three saddle setback conditions were compared: a *Recommended* condition which included values of saddle height and setback based on individual anthropometric measurements, a *Backward* (10% more backward) and a *Forward* (10% more forward) conditions. The setup of all other settings was standardised. For the three conditions, participants were instructed to perform a 3minute trial while keeping cadence (90rpm) and power (200W) constant.

Results: Results showed that the timing (~160° of pedalling cycle) of the peak of tibiofemoral compressive force remained unchanged across saddle setback conditions. Contrary to what some epidemiological studies earlier suggested this study indicates that sitting close to the handlebar (even closer than the 5 cm of the UCI regulation) was not associated with an increase of patellofemoral and tibiofemoral forces. Oppositely, sitting backward may be more detrimental as it leads to higher tibiofemoral forces (Table 1). A 15% increase was found in a ~6 cm change of saddle setback. Those results balance previous findings that reported a mechanical advantage associated with sitting more backward.

Discussion: In a whole, this study brings new insights on the underlying mechanisms of tibiofemoral force in cycling that are of importance for a safe training and for rehabilitation protocols. Indeed, results further explained that the peak joint force was linked neither to the peak of force applied to the pedal nor to the peak of quadriceps force but to the increasing of eccentric hamstring force at the end of the downstroke phase, just before the transition toward the upstroke.

Conclusions: While it was previously reported that sitting more backward increases effectiveness in steady-state pedalling, the present study would oppositely prevent for using an important saddle setback. This underlies the difficult compromise between performance and health and reflects the complexity of defining an "optimal saddle position" and establishing bike fitting guidelines. Subsequently, our results suggest that UCI recommendations (1.3.013), which only regulate the maximal forward saddle position (saddle setback > 5 cm), but neither its backward position nor saddle height, may need to be revised.

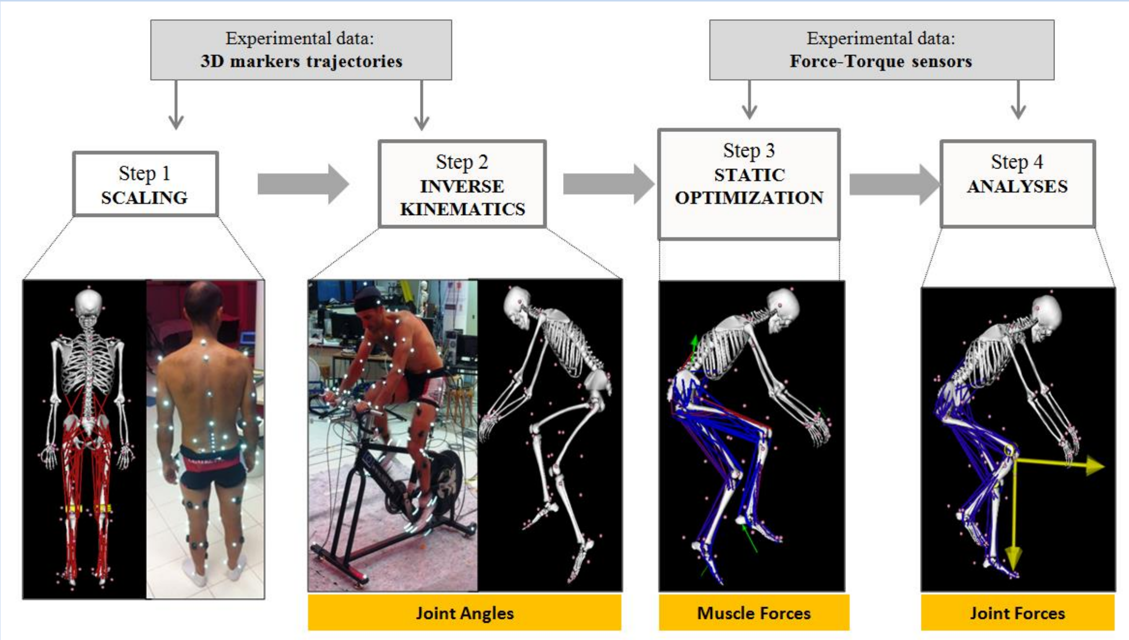

Figure 1. Workflow of the computation of knee joint forces.

Table 1. Mean (SD) of pedal force, index of crank cycle, extensor/flexor muscle force and knee angle at the time of peak of Tibiofemoral (TF) compressive force.

	Backward	*Recommended*	*Forward*
TF compressive force (N)	-732.9 (280.5)	-666 (267.1)	-637.1 (260.2)*
Pedal force (N)	-48.5 (43.1)	-52.1 (37.0)	-41.4 (22.5)
Index of crank cycle (°)	158.0 (9.4)	159.5 (9.3)	156.4 (10.7)
Quadriceps muscle force (N)	68.8 (142.0)	62.6 (97.8)	81.2 (91.4)
Hamstrings muscle force (N)	538.3 (242.2)	451.9 (198.2)	437.6 (247.9)*
Knee angle (°)	-23.6 (8.9)	-26.0 (9.9)	-27.3 (6.9)*

* Significantly different from *Backward*

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