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

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Abstract

Background: There exists a great range of possibilities offered to cyclists to adjust their equipment. The influence of some bike adjustments as well as the interactions between them on the performance and/or the biomechanics of pedalling has been extensively studied but the setup of an optimal saddle setback remains controversial. Saddle setback is commonly associated with KOPS - Knee Over the Pedal Spindle - that means that saddle setback should allow the inferior pole of the patella to be at the vertical of the pedal spindle when the pedal is at 3 o'clock. However the rationale for this is unclear even if a few opinion articles suggested that exceeding this location may engender patellofemoral pain syndrome. According to UCI regulations, the horizontal distance between the chainset centre and the anterior portion of the saddle shall be a minimum of 5 cm, no maximum is recommended and, again, with no scientific support provided. Furthermore, this rule does not take the cyclist's anthropometry into account and other disciplines such as track cycling or triathlon are not subject to this regulation, permitting a smaller setback. From a performance point of view, it is known that sitting more forward allows for an increase in maximal power production but the evidence relating saddle setback to pedalling effectiveness at steady state remains inconclusive.

Purpose: The objective was to investigate the effect of saddle setback on pedalling effectiveness through the analysis of two indices based on the force applied to the pedal and the mechanical crank work respectively.

Methods: Ten well-trained (8.5 ± 6.75 years of experience in competition) cyclists volunteered to participate in the study. A stationary cycle ergometer (SRM, Schoberer, Germany) was instrumented with two six-load component force sensors (Sensix, Poitiers, France) that were integrated in the pedals. 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) condition. For the three conditions, participants were instructed to perform a 3minute trial while keeping cadence (90rpm) and power (200W) constant. Pedalling effectiveness was evaluated through two parameters. The index of force effectiveness represents the ratio of the component of force that is tangential to the chainset on the total force applied to the pedal. A new complementary index of work effectiveness was developed; it represents the ratio between the cumulative positive (+) work and the cumulative total work. It resulted in the following equation (1):

$$\text{Index of work effectiveness} = \frac{\int_{ti}^{tf}(\tau_{right}\,\omega)^{+}dt + \int_{ti}^{tf}(\tau_{left}\,\omega)^{+}dt}{\int_{ri}^{tf}[|\tau_{right}|\,|\omega| + |\tau_{left}|\,|\omega|]dt} \quad (1)$$

With τ the chainset torque and ω the angular velocity.

Results: In comparison with a forward position, sitting backward significantly decreased 5 % cumulative total work, increased index of work effectiveness (84.2 ± 3.7 versus 82.0 ± 4.7 %) and increased index of force effectiveness (41.7 ± 2.9 versus 39.9 ± 3.7 and 36.9 ± 0.7 %) (Figure 2).

Discussion: Mechanical work calculated from the integration of instantaneous power over time differs from when assumed to be the product of average power and duration of the trial (200W*30s= 6000J). Our calculation takes into account the intra-cycle variations of instantaneous power that lead to an actual cumulative work of approximately 14000 J and more importantly was sensitive to pedalling technique (Figure 3). This index demonstrated that saddle setback impacts the amount of negative power and consequently the effectiveness of the pedalling technique from a 'mechanical work' point of view: even if cyclists produced the same average power of 200 W, in the *Forward* condition they had to produce notably more positive work than in the *Backward* condition in order to compensate the greater amount negative work during the upstroke phase. Conclusions based on the findings of this study should still be drawn with caution as pedalling technique effectiveness may not reflect overall efficiency. Finally, it remains to be verified whether using of greater saddle setback would not detrimentally affect the occurrence of knee injuries.

Conclusions: The present study demonstrates that sitting backward offers an advantage in terms of pedalling effectiveness compared to sitting more forward. Furthermore, we propose a new index based on work effectiveness that outmatches the bike fitting context and may be advantageously reused in investigations related to the evaluation of mechanical work and its effectiveness.

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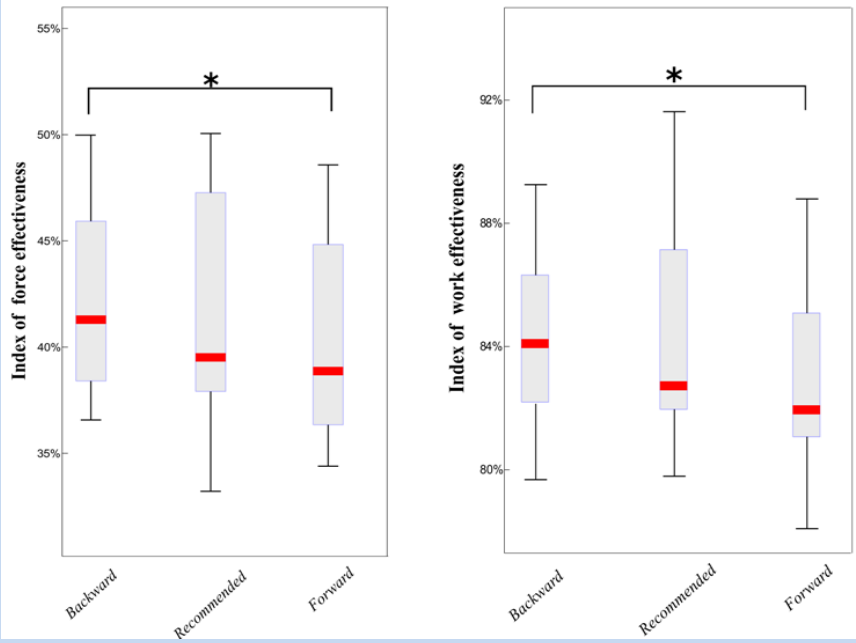

*Figure 1. Comparison of both indexes of pedalling effectiveness in the three posture conditions. For each box plot, the central mark, edges of the box and whiskers represent the median, the 25th and 75th percentiles, and the extreme data points respectively. * indicates a significant difference.*

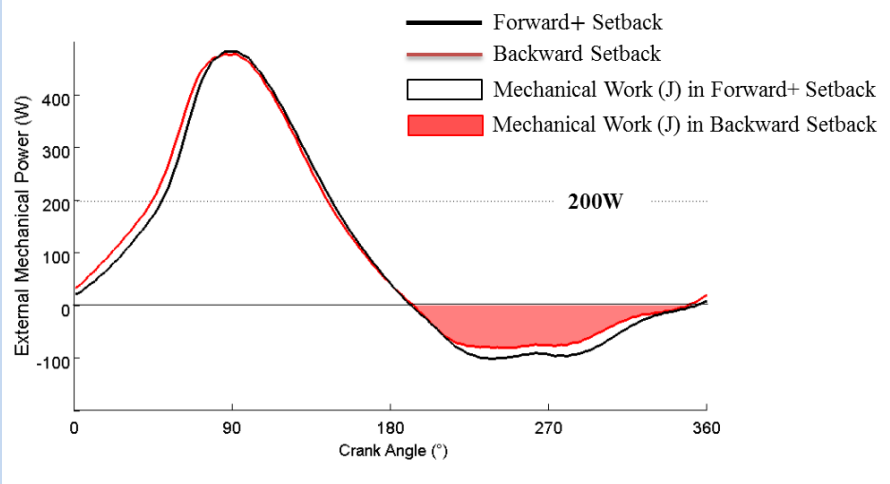

Figure 2. Comparison of intra-cycle variations of mechanical power between two saddle setback conditions: Forward and Backward (from one representative participant, average across all cycles of the condition). Areas show negative mechanical work.

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