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Abstract

Biomechanical determinant of sitting comfort in cycling, a case study series

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1. Introduction

Cycling can lead to traumatic injuries such as irritations or musculoskeletal pains which are caused by a bad interaction between the cyclist's buttocks and the saddle, causing an alteration of the perception of the sitting comfort (Breda et al. 2005; Larsen et al. 2018). They are mainly due to tissue compressions or deformations that are associated with biomechanical seating factors, like the saddle surface pressure repartition or the shear forces.

Several studies investigated the effect of several saddles characteristics as the dimensions, the shapes, or their set up on the pressure repartition and perceived comfort (Hynd, Cooley, and Graham 2017; Larsen et al. 2018). However, an infinite number of saddles with different characteristics could exist, which makes it difficult to predict their impacts on the biomechanical and perceptual sitting factors.

To address this issue with car seating interfaces, several authors investigated the principle biomechanical seating variables that are associated with the seating perceived comfort during driving. The pressure repartition and the shear forces are the main parameters that impacted the seating comfort. Yet, no studies reported similar results during cycling (Beurier, Cardoso, and Wang 2017; Hiemstra-van Mastrigt et al. 2017).

Therefore, this preliminary study aimed to investigate the changes in saddle shear forces following an improvement of the sitting perceived comfort during cycling. We suggested that the lower dissipation of the force generated by the cyclist's buttock from the shear force would increase the force transmitted to the seat tube. Therefore, it is hypothesized that the improvement of the sitting perceived comfort will be associated with the increase of the tangential force transmitted to the seat tube.

2. Materials and Methods

Subjects- Four males (age: 21.7 ± 4.6 years, height: 182.7 ± 10.1 cm; body mass: 71.3 ± 14.2 kg, body mass index: 20.6 ± 2.4) and 1 female (age: 25 years, height: 170 cm; body mass: 58 kg, body mass index: 20) trained competitive road cyclists volunteered to participate in the study. Subjects were accepted to participate in the study if they reported a perceived sitting comfort during their training on their road bike inferior or equal to 6 on the 0-10 VAS comfort scale (0 No comfort – 10 Extremely strong comfort) (Kyung, Nussbaum, and Babski-Reeves 2008).

Design- To compare biomechanical sitting factors before and after improvement of the perceived sitting comfort, participants performed with their personal bicycle two times similar cycling exercises of 20 min on a treadmill (RL2700E, Rodby, Sweden). It was constituted of 4 blocks of 5 min with slopes of 1, 3, 6, and 9% respectively. The experimenter controlled that both 5 min blocks performed at the same slope during the two separated 20 min cycling exercises were performed with the same gear ratio. The treadmill speed was adjusted to clamp the participants close to a RPE CR10 of 4 (Borg 1998). The sitting comfort was assessed at the end of each 20 min session with the 0-10 VAS comfort scale (0-very uncomfortable-10 very comfortable). Moreover, saddle pressure and shear forces measurements were performed with a saddle pressure system (Gebiomized, Münster, Germany), and a custom-made sensor (figure 1). Gebiomized saddle pressure system allowed measuring the anterior-posterior and medial-lateral mean displacement of the force application point (in mm). The custom-made sensor, by its conception, allowed measuring the anterior-posterior and medial-lateral tangential forces transmitted to the seat tube. The amplitude of the time synchronous average of the sensor signals was calculated under Matlab (Matlab, Mathworks, USA).

Between the first and the second treadmill exercises, a fitting optimization session was completed following the Bikefitting institute recommendations (Bikefitting, Maastricht, Netherland). This aimed to improve the perceived sitting comfort of the subjects. This session was composed of 5 steps 1) perceived comfort assessment during cycling and shoe cleats settings; 2) anthropometrical characterization; 3) dynamic fit; which aimed to individually optimize the cyclist's positions according to the bike fitting recommendations; 4) pedaling analysis which aimed to quantify and optimizing the dynamic pedaling activity performed by the cyclist's on both pedals, during the all pedaling revolution; and 5) saddle model selection and setup optimization; that consisted in optimizing the sitting comfort of subjects. According to the individual problematics, different adjustments could be performed as changes as saddle position and model changes, handlebar position changes, or shoe cleats setting.

Statistical Analysis- A non-parametric Wilcoxon test was performed to investigate the differences in the anterior-posterior and medial-lateral tangential force transmitted to the seat tube, application point force-displacement, and perceived comfort measurements assessed before and after the fitting optimization session, during each 5-min block of the treadmill tests. Cohen effect size was calculated for each set of data (Cohen, 1988). Cohen's *d* classification of effect size magnitude was used, whereby d = 0.2–0.49 = small effect; d = 0.50–0.8 = moderate effect and $d > 0.8$ = large effect. Data were presented as median[interquartile range].

3. Results

After the fitting optimization session, there was a statistical increase in the mean tangential force amplitude in the anterior-posterior direction (Me=36[37]; +49 ± 52%, $p<0.05$, $d>0.8$ at 1% slope; and Me=10[9]; +36 ± 66%, $p<0.05$, $d>0.8$ at 3% slope) and in the medial-lateral force (Me=40[36]; +33 ± 22%, $p<0.05$, $d>0.8$ at 1% slope; and Me=10[8]; +22 ± 30%, $p<0.05$, $d>0.8$ at 3% slope), but not at 6 and 9% slopes (Figure 2). However, no statistical difference was observed concerning the point force-displacement in these directions.

Finally, the perceived sitting comfort increased after the fitting session ($p<0.001$, +180 ± 109 %; Figure 3).

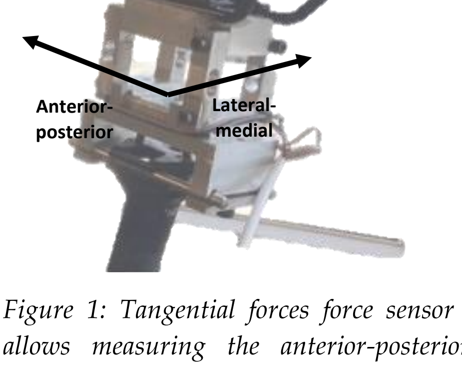

Figure 1: Tangential forces force sensor which allows measuring the anterior-posterior and

medial-lateral tangential forces transmitted to the seat tube.

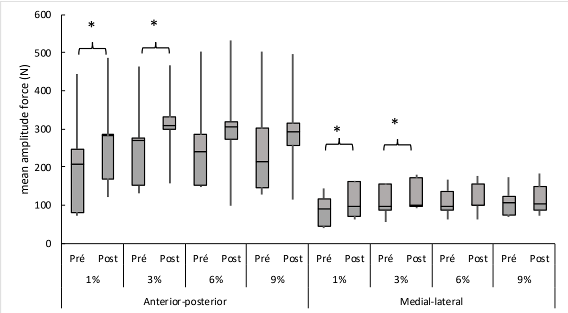

Figure 2: Mean amplitude of the anterior-posterior and medio-lateral shear forces in Newton (N) measured at each slope during the treadmill test, PRE and POST the fitting optimization session

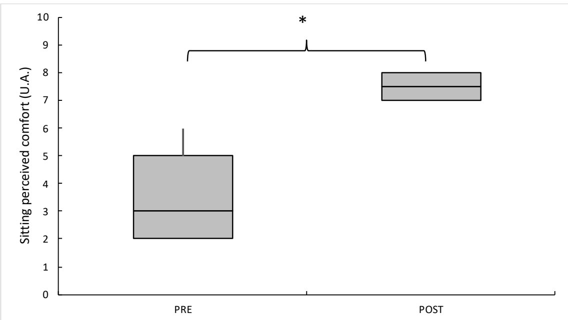

Figure 1 Sitting perceived comfort during the treadmill test performed PRE and POST the fitting optimization session

4. Discussion

The increase in tangential forces transmitted from the cyclists to the seat tube in the anterior-posterior and medial-lateral direction at a slope of 1% could be caused by the better stability of the pelvic on the saddle after the fitting session. Such hypotheses are supported by the absence of differences in the mean force application point displacement in the anterior-posterior and medial-lateral directions. This suggests a reduction in the dissipation of the tangential forces generated by the cyclists into shear forces between buttock tissues and the saddle. The absence of statistical increase in tangential forces transmitted to the seat tube for more important slopes (3, 6, and 9%) could be due to the gravity force promoting a pelvic retroversion. This would alter the homogeneity of pressure repartition between the sit bones and the pubic, therefore altering the buttock stability on the saddle. Such evolution of these biomechanical sitting factors would participate in the improvement of the sitting perceived comfort in cycling. Optimizing such biomechanical parameters would allow the prevention of sitting-related traumatic injuries in cycling.

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Conflicts of Interest: The authors declare no conflict of interest

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