Biomechanical determinants of sitting comfort in cycling: a case study

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ÉQUIPE CYCLISTE

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Culture
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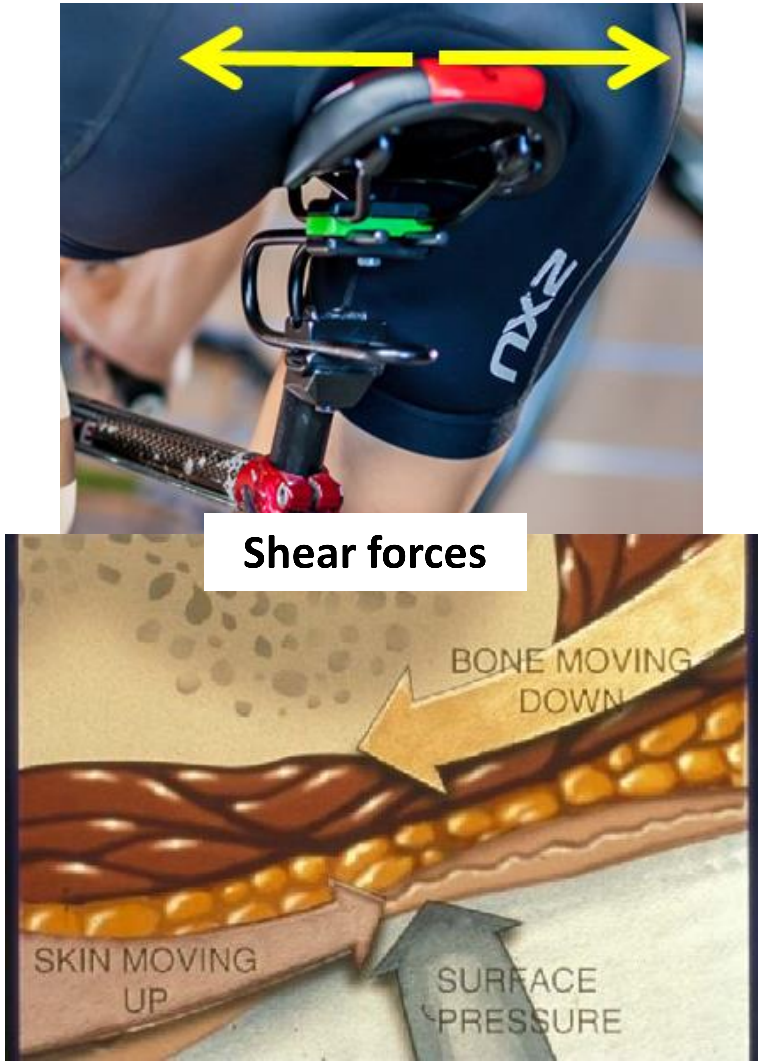
Introduction-Objective-Protocol-Results-Conclusion

Saddle ☛ musculoskeletal pains or irritations alter the comfort (Breda et al., 2015; Larsen et al., 2018)

One consequence of the tissue shear loading (Wilson et Bush., 2007)

Could be measured with saddle force sensors (Wilson et Bush., 2007, Beurier et al., 2017)



Perceived sitting comfort

How shear forces impact the perceived sitting comfort in competitive cyclists ?

Sensor Design

4 strain gauges

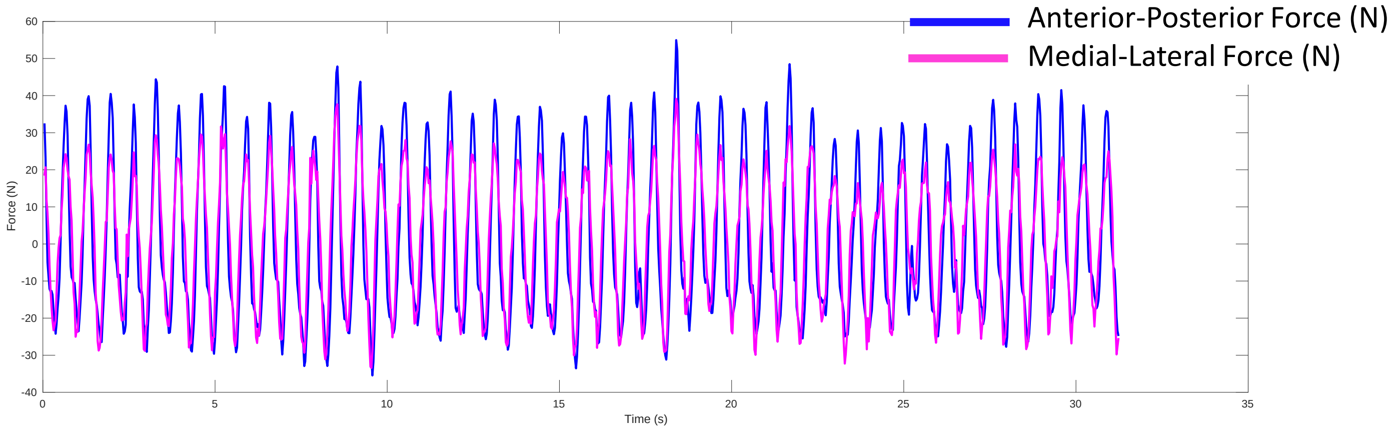
Arduino Microcontroller

☛ Measure shear forces applied on saddle in:

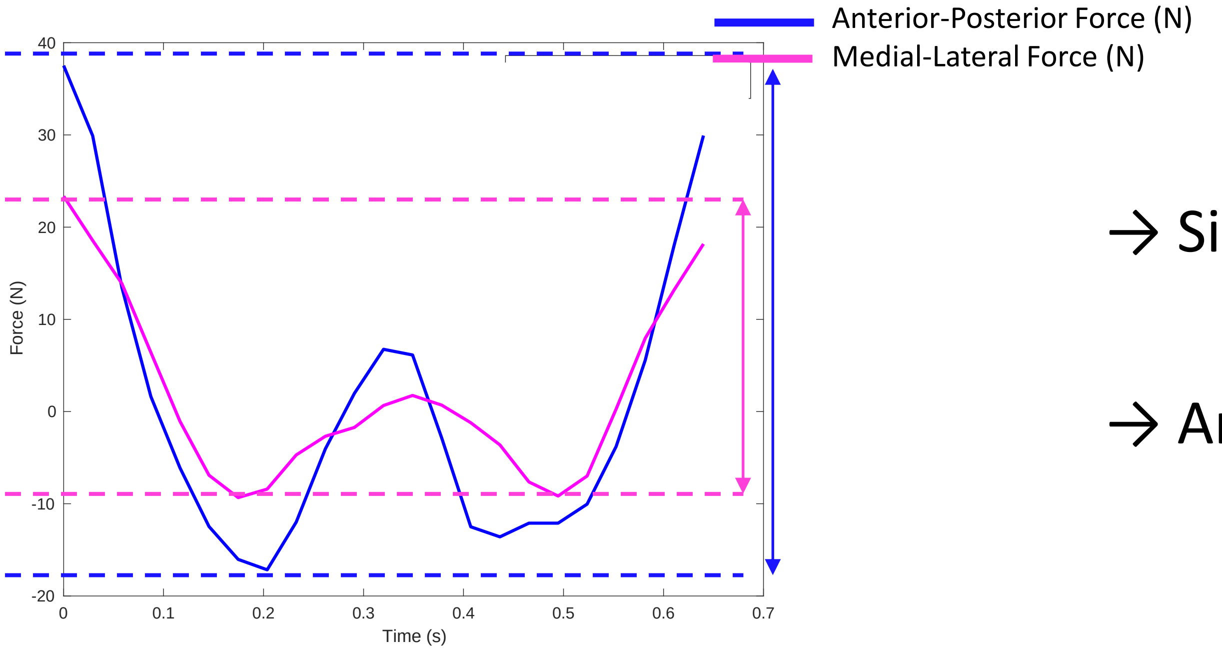
→ Anterior-posterior ($\vec{F}x$) *and*

→ Lateral-medial ($\vec{F}y$) directions

Signals processing



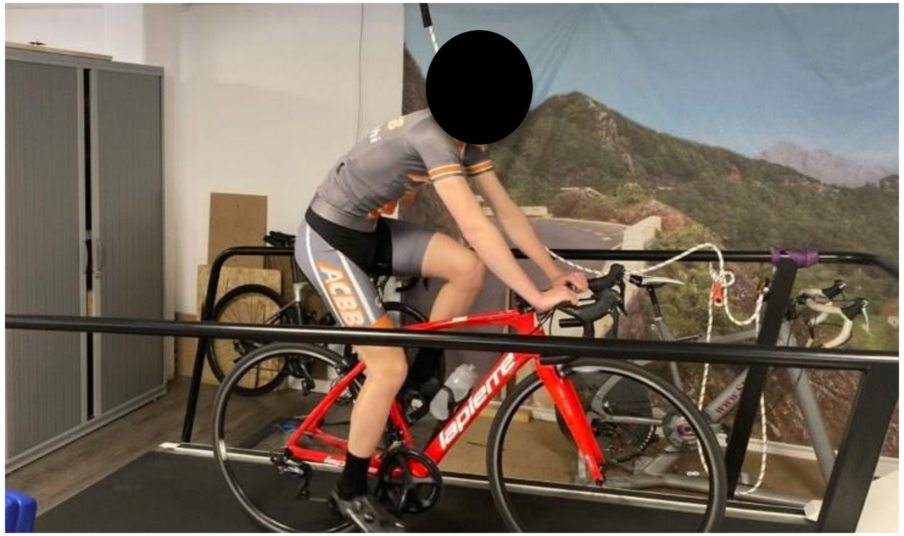
→ $\vec{F}x$ and $\vec{F}y$ signals clean using a moving average filter



→ Signal time synchronous average

→ Amplitude of the signal (in N)

	Male	Female
N	5	1
Age (year)	26 ± 11	25
Mass (kg)	69 ± 14	58
Height (cm)	178 ± 10	170



1 Day laboratory test: 2 × 20 min treadmill exercise

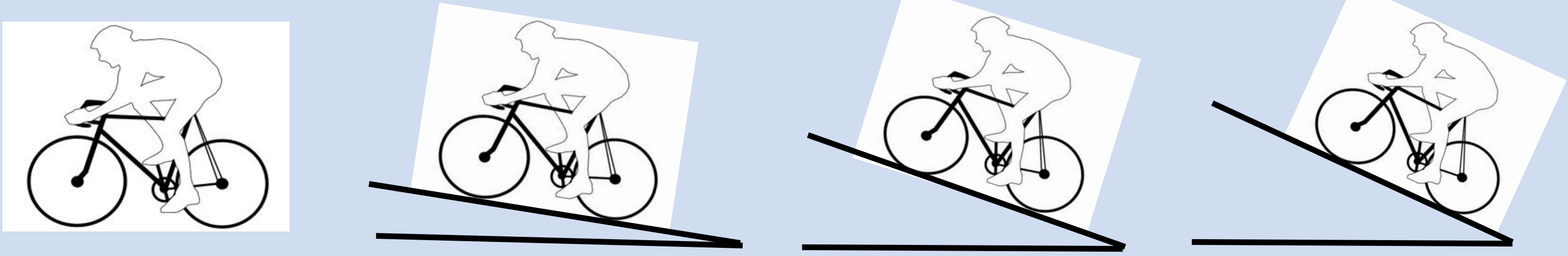
Before (PRE) and After (POST): a bikeffiting procedure that aimed to optimize the sitting comfort

4 x 5 min of pedalling on a treadmill at RPE CR10 of 4, at 4 slopes (1, 3, 6 and 9%)

EXERCISE

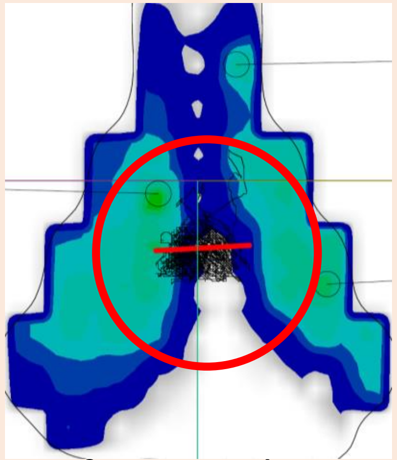
PRE and POST

5 min | 5 min | 5 min | 5 min



1% | 3% | 6% | 9%

MEASURES



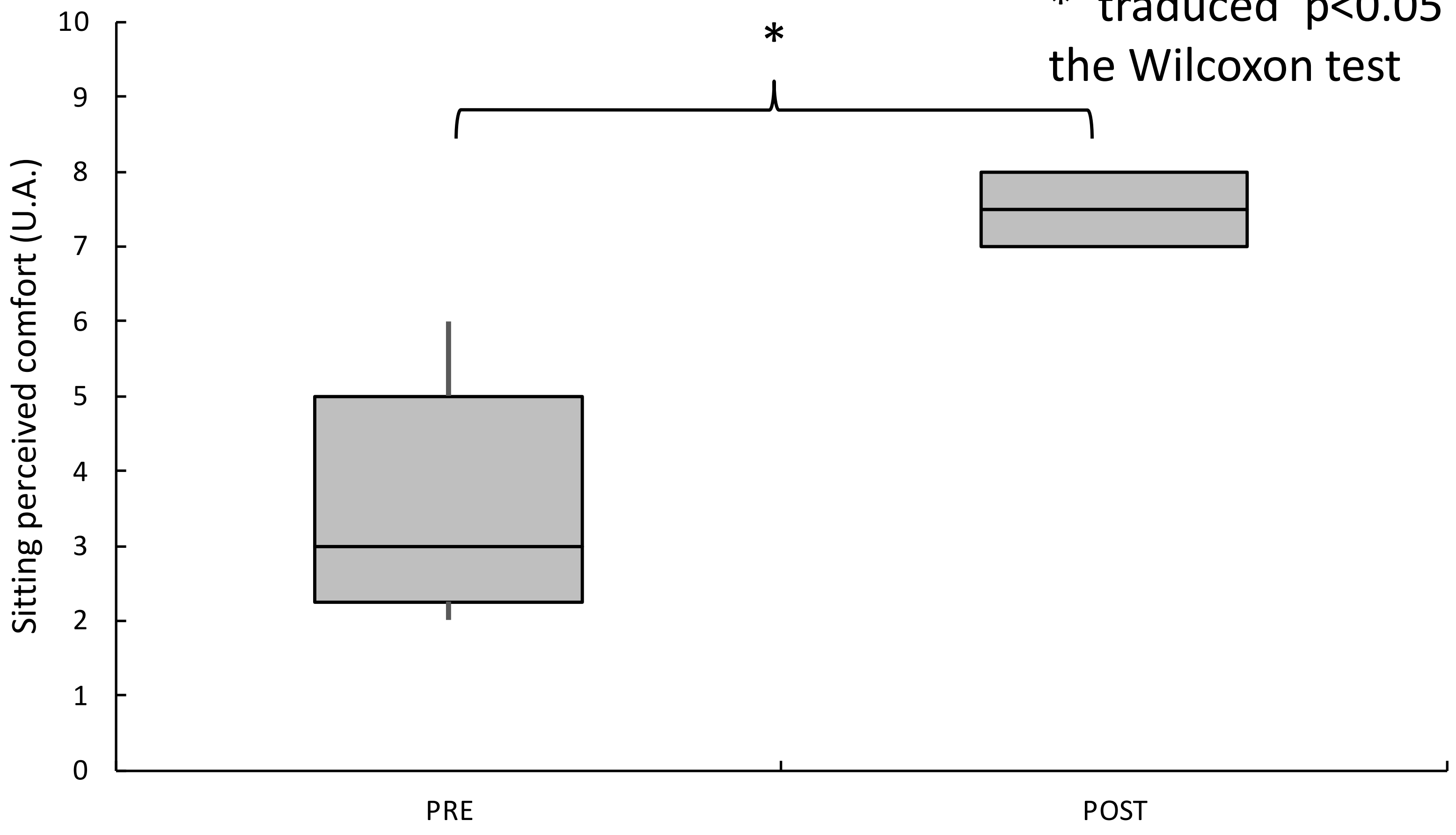
Point force application displacement in the anterior-posterior (Fx) et medial-lateral (Fy) direction

Shear forces in the anterior-posterior (Fx) et medial-lateral (Fy) direction

ECHELLE DE CONFORT

10	Très Confortable
9	
8	Confortable
7	
6	Légèrement Confortable
5	Neutre
4	Légèrement Inconfortable
3	
2	Inconfortable
1	
0	Très Inconfortable

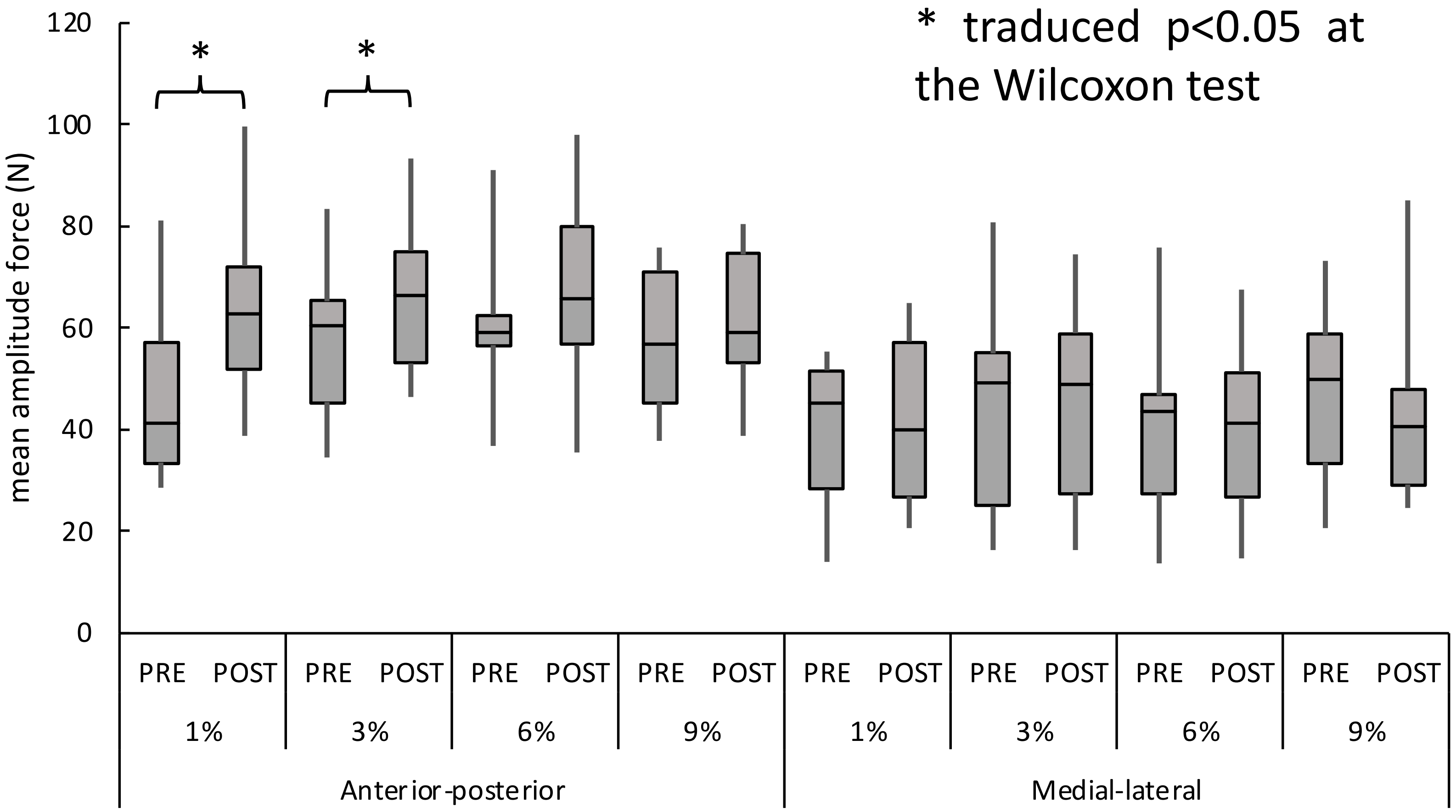
Perceived sitting comfort
(0 very uncomfortable – 10 very comfortable)



* traduced $p<0.05$ at the Wilcoxon test

☛ Increase in the mean perceived sitting comfort after the fitting optimization session

➤ +150 ± 106 %

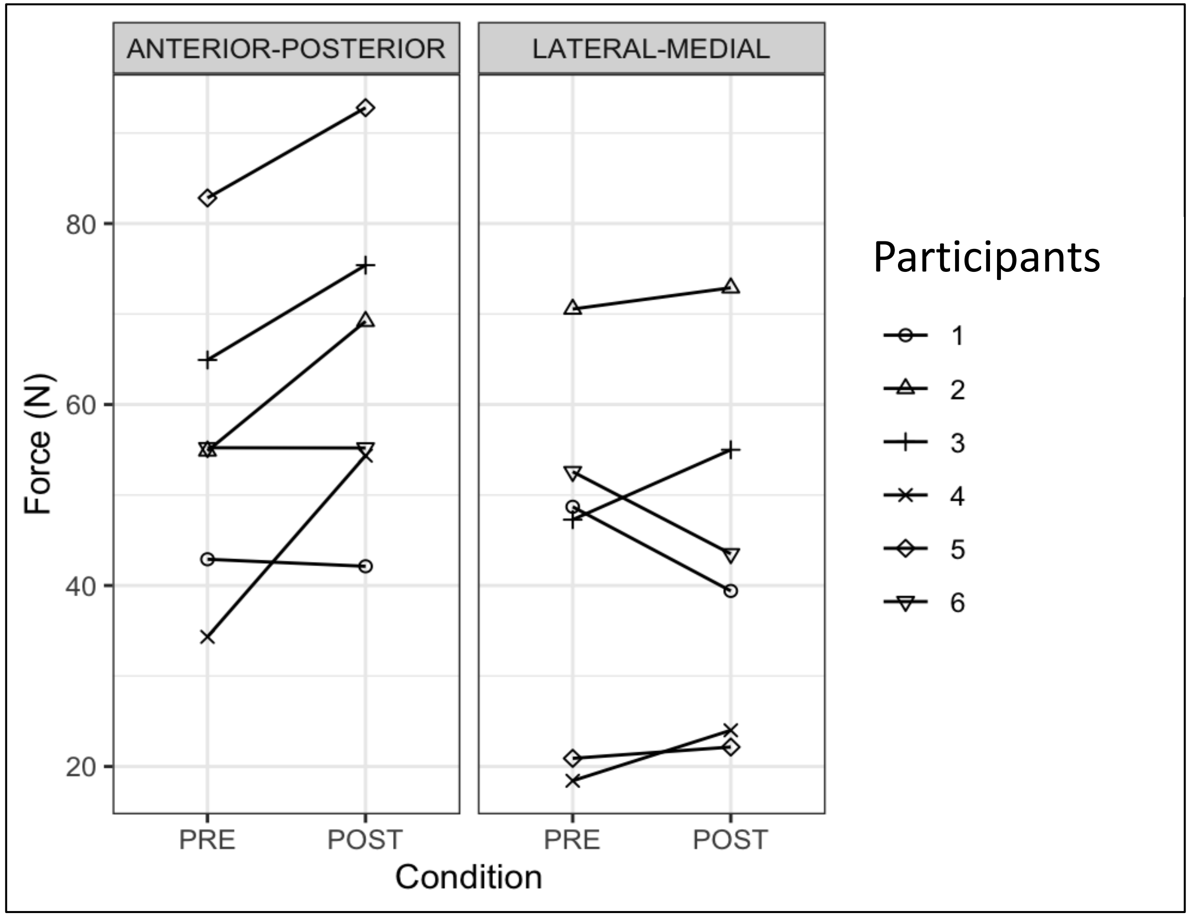


* traduced $p<0.05$ at the Wilcoxon test

☛ Increase in the mean anterior-posterior force amplitude:

➤ +40 ± 17% at 1%

➤ +27 ± 31% at 3%



Mean(N) 55.8N 64.8N 43.1N 42.8N

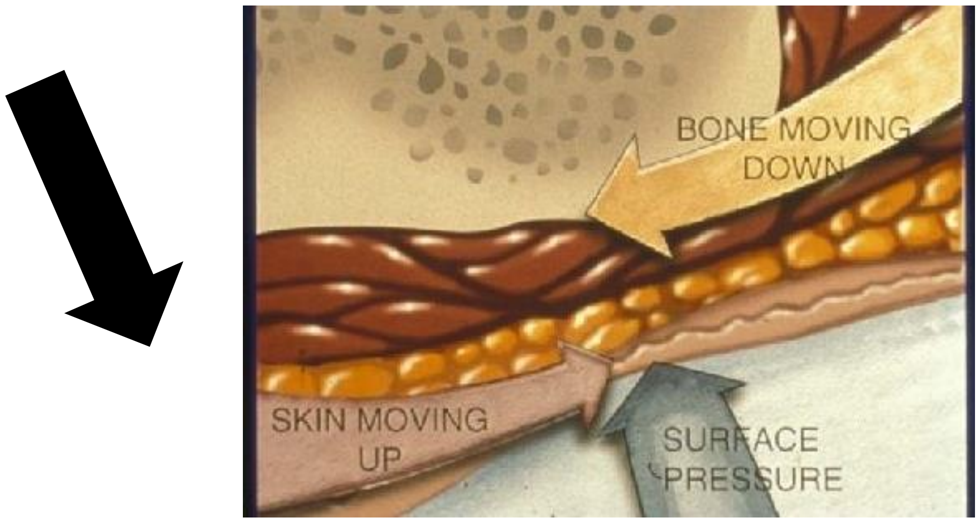
☛In average for all slopes, we observed an increase:

➤in the anterior-posterior direction for 5 participant

➤in the lateral-medial direction for 4 participant

☛ No differences in the displacement of the point force application, in both directions

Increase in Anterior-posterior forces → Better pelvic stability on the saddle and less shear forces



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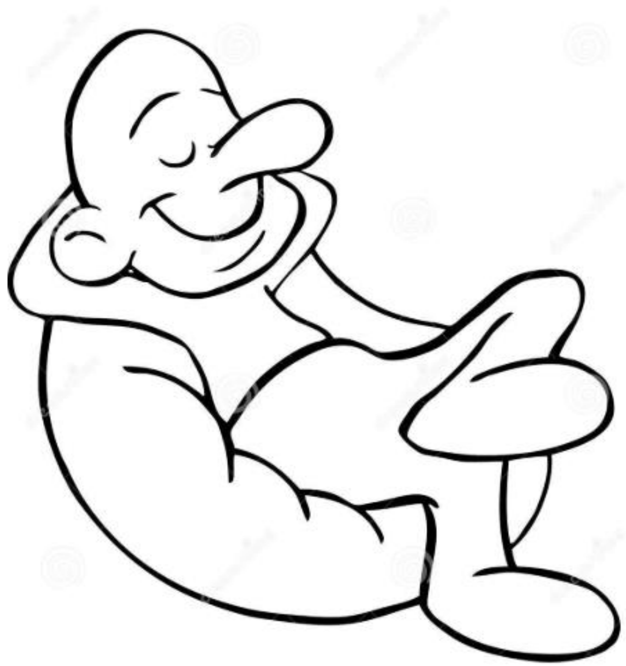
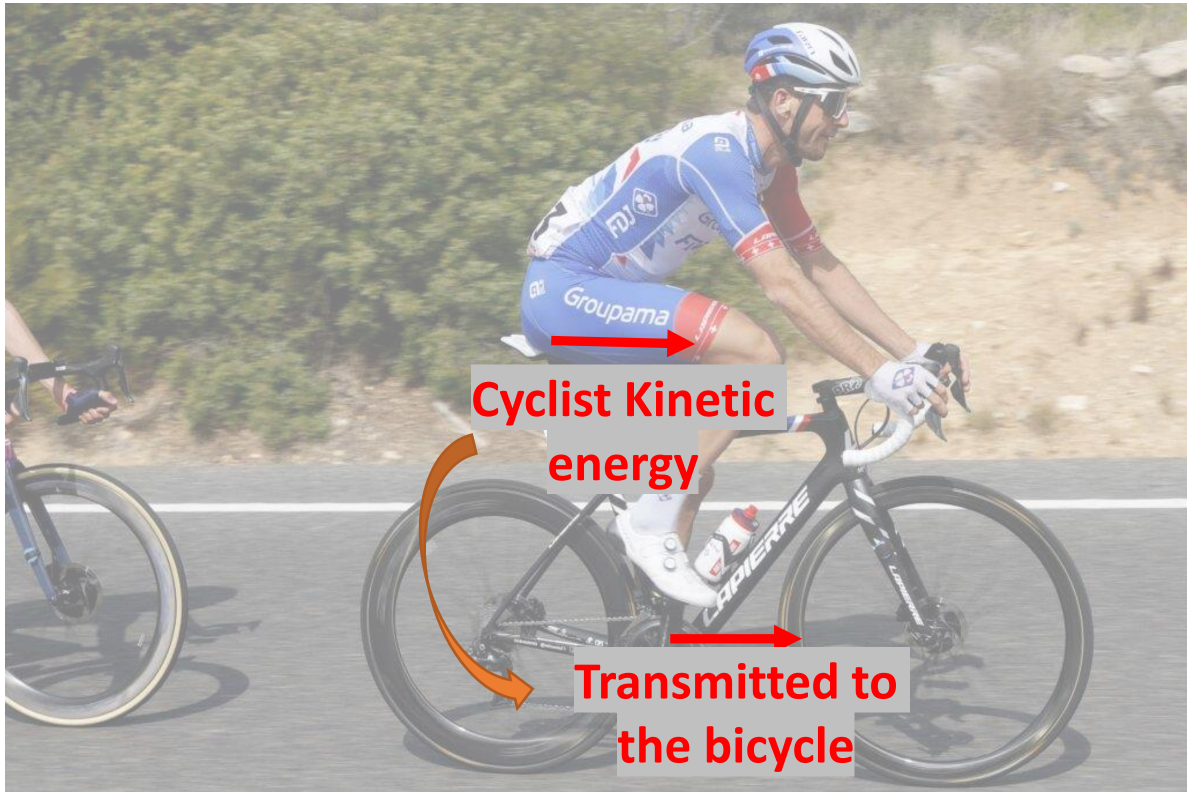


Lower level of shear forces between buttock and saddle would improve the sitting comfort ?



Increase pelvic stability on the saddle = More kinetic energy transmitted by the cyclists to the bike

Could improve pedalling efficiency, and contributing to improve comfort

Practical application

Could have major interest for bikefitting pactiser, to help customers to choose the more adapted saddle

Thank you for your attention

References:

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Matich, Sebastian, Markus Hessinger, Mario Kupnik, Roland Werthschützky, and Christian Hatzfeld. 2017. 'Miniaturized Multiaxial Force/Torque Sensor with a Rollable Hexapod Structure: Miniaturisierter Kraft-Momenten-Sensor Auf Basis Einer Gerollten Hexapod-Struktur'. *Tm - Technisches Messen* 84(s1):138–42. doi: 10.1515/teme-2017-0046.

Wilson, Chisom, and Tamara Reid Bush. 2007. 'Interface Forces on the Seat during a Cycling Activity'. *Clinical Biomechanics* 22(9):1017–23. doi: 10.1016/j.clinbiomech.2007.06.004.

Supplementary Slide

CALIBRATION OF THE SENSOR

☛2, 10 and 20kg in $\overrightarrow{Fx}$, $\overrightarrow{Fy}$, $\overrightarrow{Mx}$ and $\overrightarrow{My}$ directions

☛ Calibration Matrix :

$$\begin{bmatrix} \overrightarrow{Fx} \\ \overrightarrow{Fy} \\ \overrightarrow{Mx} \\ \overrightarrow{My} \end{bmatrix} = \begin{bmatrix} U1 \\ U2 \\ U3 \\ U4 \end{bmatrix} {K^{-1}}^{T}$$

With U1, U2, U3 and U4 the tension measured by the 4 strain gauges (Matich et al., 2017).

☛ The 4 columns of the inverse transpose matrix ${K^{-1}}^{T}$ are the slopes of the linear regression between the outputs voltages and the applied load.

$$K = \begin{bmatrix} U1_{\overrightarrow{Fx}} & \cdots & U1_{\overrightarrow{My}} \\ \vdots & \ddots & \vdots \\ U4_{\overrightarrow{Fx}} & \cdots & U4_{\overrightarrow{My}} \end{bmatrix}$$

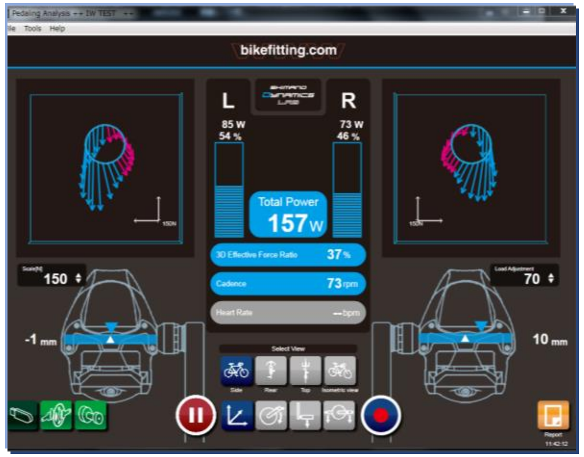
Supplementary Slide

BIKEFITTING PROCEDURE

1) Shoe Cleat setting

2) Dynamic Analyze

3) Pedalling analyze



4) Saddle model selection