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# Preliminary study of the effect of saddle fitting on a rider's pelvic range of motion

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## 1. Introduction

The saddle fitting to the rider-horse pair plays a very important role with regards to wellbeing and performance in equestrian sports. However, the saddle fit remains highly subjective when saddles are sold in stables. The saddle has been shown to have an impact on rider stability and kinematics (Mackechnie-Guire et al. 2018, Clayton et al. 2018). Yet, these studies have not been conducted when there have been specific adaptations to a saddle. New methods for analyzing biomechanical parameters specific to the rider were created following the emergence of rider pelvic pitch range of motion assessment (Eckardt et al. 2016). These methods have been the subject of numerous publications (Münz et al. 2013) but have not yet been applied to the specificities of saddle fitting in stables. The aim of this preliminary study is to measure the impact of saddle fitting on the rider's pelvic pitch range of motion (ROM).

## 2. Methods

### 2.1 Riders

Three riders (R1, R2, and R3, average age of 29±5 years) took part in the study with their own horses and equipment. They were all women practicing show jumping at amateur level.

### 2.2 Data Collection

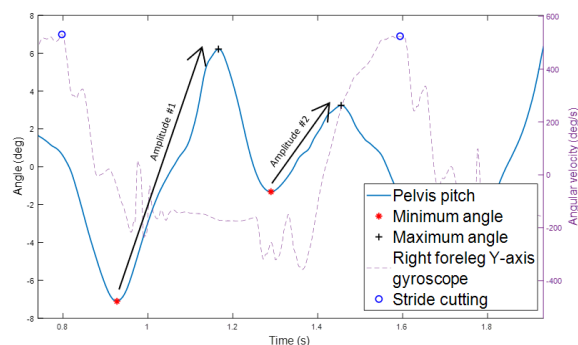
Each dyad was equipped with two synchronized IMUs (Blue Trident Sensors, @Vicon), one placed on the horse (cannon of the right foreleg) and one on the rider (S1 vertebrae). For this experiment, we used only triaxial gyroscope (1125 Hz). First, the dyads warmed up as usual using their regular equipment. Next, measurements were taken whilst riding 20m in straight lines at three gaits (walk, rising trot, and canter) and in both reins, testing four different saddles in a random order.

The saddles tested were identical jumping saddles in design, with the modification of a single variable parameter on each of them. These variations corresponded to fine modifications of a saddle that we have defined as our standard (A). The A saddle was therefore reproduced in triplicate, with only one parameter changing each time. The seat was hollowed out by 6mm for saddle B. The width of the quarters was reduced by 15mm for saddle C, and the padding was raised by 10mm for saddle D.

### 2.3 Data Processing

Data processing was carried out using Matlab (R2023b). The pelvic pitch angle was obtained from the gyroscopic data on the transverse axis of the sensor placed on the rider's pelvis. Data were filtered with a fourth-order high-pass filter and a cut-off frequency of 1 Hz. The recordings were divided into strides using gyroscopic data from the IMU placed on the right foreleg. A complete stride corresponds to the time between two successive supports of this foreleg (Münz et al. 2013). A minimum of 50 strides was collected for each condition.

The ROM was obtained as the difference between the minimum and maximum angles of the pelvis during a stride. As the riders in this study are doing rising trot, we get two different amplitudes during each half stride. We can observe amplitude #1, corresponding to the standing phase of the rider. The amplitude #2 corresponds to the sitting phase (Figure. 1). In this exploratory data processing, only the sitting phase of the rising trot was analyzed (amplitude #2) because it's when the rider is closest to the saddle.



**Figure 1.** Rider's pelvis pitch angle in rising trot

Intra-subject and inter-saddle comparisons were made from the pitch amplitudes measured. Normality distribution using Shapiro-Wilk tests and descriptive statistics were performed. Kruskal-Wallis (KW) and, if necessary, Mann-Whitney (MW) tests were also used for inter-saddle comparisons.

## 3. Results and discussion

As the data were not normally distributed, non-parametric KW tests were used. The results of these tests show that gyroscopic data does not follow the

same distribution for each of the three riders ( $p < .001$ ). R1's results show a significant higher pelvic pitch ROM with saddles C and D than with saddles A and B. This rider had the highest ROM with saddle D and the lowest ROM with saddle B. R2 has higher ROM values with saddles A, C and D with no significant differences between them and also the lowest ROM with saddle B. R3 had the highest ROM with saddle D, but also the highest interquartile range with this saddle. This rider had the lowest ROM with saddle B. The three riders had a significant lower ROM with saddle B, which can be explained by the fact that this saddle has a semi-hollow seat whereas the other three have a flat seat. R2 and R3 have the most ROM with saddle D. Indeed, saddle D is thicker than the others at the front of the panels and the balance of the saddle can affect the rider's position (Mackechnie-Guire et al. 2018). As Wilkins et al. (2020) have shown, individual strategies specific to each rider have been observed in this study. This is why they were assessed individually, and different biomechanical strategies were observed with the four saddles.

**Table 1.** Median ( $^{\circ}$ ) and interquartile range (IQR) ( $^{\circ}$ ) of the ROM of riders' pelvis

Saddle	R1		R2		R3	
	Median	IQR	Median	IQR	Median	IQR
A	2.2 <sup>*C,D</sup>	1.1	6.5	2.3	10.9 <sup>*B,C,D</sup>	3.1
B	1.5 <sup>*C,D</sup>	1.5	3.8 <sup>*A,C,D</sup>	1.9	4.3 <sup>*A,C,D</sup>	2.6
C	3.5 <sup>*A,B</sup>	1.3	6.3	3	9.5 <sup>*A,B,D</sup>	2.6
D	3.8 <sup>*A,B</sup>	1.3	6.5	2.4	14.7 <sup>*A,B,C</sup>	5.2

\* significant difference between saddle  $p < 0.05$  (Mann-Whitney test)

The results presented in Table 1 represent only the ROM that occurred in the right rein (clockwise direction) rising trot. During the measurement protocol, the riders performed the same exercises in the left rein (counterclockwise direction). The same trends were observed in both reins, but with different significance levels for some of the saddles.

The main limitation of this preliminary study is the relatively small population size. It would be relevant to extend this study to a larger population including men. Indeed, Bye & Martin (2022) have highlighted significant differences between men and women's pelvis kinematics in horse riding.

#### 4. Conclusion

The pitch of rider's pelvis measured in this preliminary study showed differences between the saddles tested. This method highlights changes in the kinematics of the rider's pelvis during modifications in saddle fitting. This measurement method could therefore be envisaged to develop a saddle fitting tool dedicated to an application of saddle sales. This development would not only help to improve the quality of saddle fitting but also quantify the impact of this practice on

performance and wellbeing. As riders often suffer back injuries, improving the quality of saddle fitting could potentially help reduce musculoskeletal disorders.

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