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## Movement asymmetry measured in sound horses trotting on a straight line

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### 1. Introduction

During clinical examination, the veterinarian assesses the horse locomotion at trot in order to detect lameness. Visual observation is used to determine the painful limb and the lameness grade. However this assessment remains subjective with large variation between veterinarians, particularly for subtle lameness (Keegan et al. 2010). To assist in the diagnostic, movement analysis systems have been used increasingly in the veterinary practice. Particularly Inertial Measurement Units (IMU) allow versatile and pervasive protocols, their limit of agreement compared with the Motion Capture is of 9–16 mm (Warner et al. 2010).

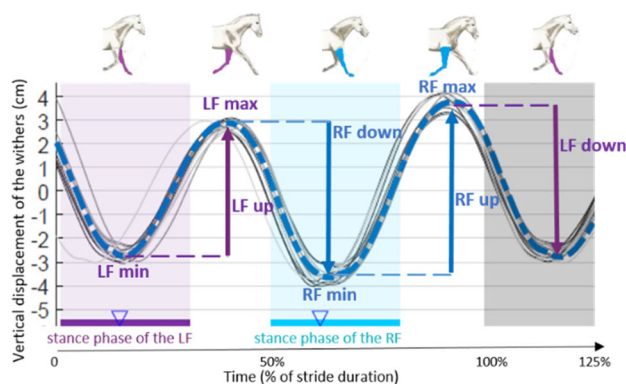
Vertical movement of the dorsal line (head, withers and pelvis), which decreases during the stance phase of the painful limb, is often used as biomarker. However, even sound horses able to perform at their maximal capacity demonstrated physiological asymmetrical gait (Kallerud et al. 2021). The definition of lame horse is then controversial (Weeren et al. 2017). Some studies measured asymmetry in a population of sound horses but the number of subjects was relatively small (Hardeman et al. 2019).

The aim of this study was to define the range of asymmetry values which characterizes a population of sound horses.

### 2. Methods

#### 2.1. Horses

49 horses of various breeds, with an average age of 7.8 (range 2–15) years, were included in the study. These horses were considered by their owner/rider able to perform at their maximal capacity. Their locomotion has been evaluated as asymptomatic by an expert clinician (specialist in equine locomotor pathology) during a complete and standardized clinical



**Figure 1.** Mean vertical displacement (cm) of the withers plotted against time (% of stride duration) of a horse with a left forelimb (LF) lameness.

**Table 1.** Mean, SD, median, 5<sup>th</sup> and 95<sup>th</sup> percentiles of asymmetry indexes for 49 sound horses.

|         |         | Mean (%) | SD (%) | Median (%) | 5 <sup>th</sup> P (%) | 95 <sup>th</sup> P (%) |
|---------|---------|----------|--------|------------|-----------------------|------------------------|
| Head    | Al-min  | -7       | 29     | -12        | -42                   | 46                     |
|         | Al-max  | -4       | 12     | -5         | -23                   | 15                     |
|         | Al-up   | -11      | 29     | -11        | -52                   | 36                     |
| Withers | Al-down | -2       | 29     | -5         | -48                   | 52                     |
|         | Al-min  | -3       | 8      | -4         | -11                   | 8                      |
|         | Al-max  | 2        | 8      | 1          | -9                    | 15                     |
| Pelvis  | Al-up   | -1       | 9      | -3         | -12                   | 16                     |
|         | Al-down | -3       | 11     | -2         | -24                   | 12                     |
|         | Al-min  | 6        | 8      | 6          | -7                    | 20                     |
|         | Al-max  | -1       | 9      | -2         | -19                   | 11                     |
|         | Al-up   | 5        | 13     | 5          | -11                   | 25                     |
|         | Al-down | 5        | 11     | 5          | -14                   | 20                     |

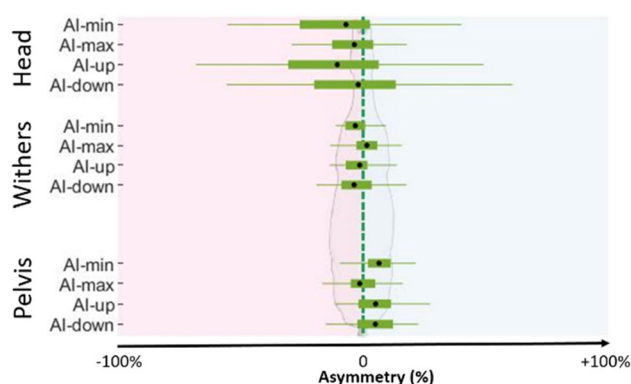
locomotor examination (straight lines and circles, on hard and soft grounds at different gaits).

#### 2.2. Data collection

Each horse was equipped with 7 IMUs placed on the head, withers, pelvis and 4 metacarpal-tarsal bones. Each IMU was composed of triaxial accelerometers and gyroscopes set to a sampling frequency of 200 Hz. Recordings were performed during the locomotor examination when the horse trotted on a straight line on an asphalt surface, held in hand. A mean (min-max) of 14.3 (5–55) trot strides were recorded per horse.

#### 2.3. Data processing

Dorsoventral displacement of the head, withers and pelvis were deduced from accelerometric data (Pfauf et al. 2005) and were normalized by the stride duration. During a normal trot stride, the trunk of the horse moves twice up and down with a double sinusoid corresponding to the right and left stance phases (Figure 1). Based on this principle, four Asymmetry Indexes (AI) were calculated and expressed as a percentage of the maximal range of motion (%).



**Figure 2.** Boxplots (minimum, 2<sup>nd</sup>, 3<sup>rd</sup> quartiles and maximum) of asymmetry indexes (AI) of 49 sound horses according to the localization (head, withers and pelvis). Means are represented as black dots.

AI-Min was the left-right difference of the lowest altitude point; AI-Max was the left-right difference of the highest altitude point; AI-up was the left-right difference of the upward range of motion during the propulsion phase; and AI-down was the left-right difference of the downward range of motion during the damping phase. Positive AI value indicates a weaker movement amplitude during the right stance than during the left stance, and negative AI value indicates the opposite.

Mean and median values, standard deviation (SD), 5<sup>th</sup> (5<sup>th</sup> P) and 95<sup>th</sup> (95<sup>th</sup> P) percentiles were calculated for the 49 sound horses included in this study.

### 3. Results and discussion

AI of the head showed a higher variability than AI of the withers and pelvis. This result should be analysed in conjunction with greater mobility of the head, which is also affected by parasitic movements inducing artefacts. Moreover head AI means were all slightly negative, which reflected a subtle decreased range of motion of the head during the Left Forelimb (LF) stance phase than during the Right Forelimb (RF) stance phase. In conventional horse training, the leader holds the rope connected to the horse's head, standing systematically to the left side of the horse. This asymmetrical posture of the handler may explain the slight movement reduction of the head during the left stance in sound horses (Table 1, Figure 2).

AI of the withers showed relatively small variability between horses and were close to zero %, meaning that the physiological asymmetry of sound horses on the withers was small.

Finally, AI of the pelvis also showed small variability between horses. AI-up, -down and -min were slightly positive, which reflected a weaker downward

movement during the right hindlimb stance phase than during the left hindlimb stance phase.

### 4. Conclusions

Sound horses showed slight asymmetries of the vertical movement of the head and pelvis (AI-min means of -7% and 6%), reflecting less movement amplitude during the left forelimb - right hindlimb stance phase. The variability was greater on the head (SD of 29% for AI-min, AI-up and AI-down) than on the withers and pelvis (maximal SD of 13%). It emphasizes the interest of biomarkers related to the trunk rather than to the head which is more affected by artefactual movements. Further studies are now needed to define asymmetry thresholds for discrimination between sound and pathological horses.

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### Disclosure statement

No potential conflict of interest was reported by the authors.

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**KEYWORDS** Horse; kinematic; symmetry; lameness

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