

Original Research

Hindquarter Movement of Sporthorse Stallions During Semen Collection



Emma L. van Beuzekom^a, Arie C. Hoogendoorn^b, Ben Colenbrander^a, Tom A.E. Stout^a, Willem Back^{a,c,*}

^a Department of Equine Sciences, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands

^b Equine Referral Clinic "De Watermolen" Equine Allround, Haaksbergen, The Netherlands

^c Department of Surgery and Anaesthesia of the Domestic Animals, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium

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ABSTRACT

Some stallions used for both breeding and show jumping perform less well in competitions during the breeding season. It has been suggested that the demands of semen collection on the back and pelvis may impair the range of motion (ROM) required for show jumping. To better understand hindquarter dynamics, this study assessed the ROM of the hindquarters during both the mounting phase (MP) and ejaculatory phase (EP) of semen collection and compared it to the ROM previously measured during show jumping. The kinematics of six warmblood stallions were studied during semen collection on a phantom. Skin markers were placed on the withers, tuber coxae, proximal femur and tibia, and distal tibia and metatarsus. During each phase, six angles were measured using recordings made with a home-video camera (60 Hz) positioned perpendicular to the phantom. The differences in joint angles between the two phases were compared statistically using commercially available software. The pelvis showed a significantly larger ROM during the MP than the EP ($P < .05$). The ROM of the hindquarters was significantly larger during both the MP and EP than reported during show jumping, and the pelvis was considerably more extended ($P < .05$). This relatively extreme flexion and extension of the pelvis during semen collection may impose different strains on musculoskeletal structures which, combined with asymmetrical lateral flexion and/or axial rotation on the phantom, may exacerbate subclinical hindquarter pain. Nevertheless, the outcome of this study would benefit from an additional, objective clinical locomotor examination combined with analysis of motion during show jumping using modern IMU sensor technology.

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1. Introduction

Sporthorse stallions are often used for both breeding and competitive purposes contemporaneously. Not surprisingly, excelling in competitive sport increases the desire of an owner to explore the commercial potential of a stallion in the breeding arena. However, stallion owners

and riders may disagree as to whether breeding and sports should be combined because one may negatively influence the other. In particular, show jumping riders often argue that the back and hindquarters of a stallion will not function optimally during show jumping if that stallion is also used for semen collection. To date, there is only anecdotal evidence that the demands of semen collection may affect jumping performance. In this respect, Pasing et al [1] investigated the influence of semen collection on salivary cortisol concentrations and heart rate in stallions, to determine whether sexual arousal or the physical exertion of breeding might negatively affect the sports performance

* Corresponding author at: Willem Back, Department of Equine Sciences, Faculty of Veterinary Medicine, Utrecht University, Yalelaan 112-114, NL-3584 CM Utrecht, The Netherlands.

E-mail address: w.back@uu.nl (W. Back).

of stallions. They concluded that semen collection is only a modest, transient stressor for sexually experienced and well-trained stallions and that this stress is unlikely to affect the physical performance of stallions in competition [1]. Other authors also suggest that mounting a phantom can be related to compromised athletic performance [2].

From a performance perspective, hindlimb retroflexion during the suspension phase over a jump has been shown to be of critical importance for the jumping capacity of a horse [3,4]. This hindlimb retroflexion over a jump requires extreme extension of the pelvis. When the hindquarters of the horse are above the fence, the lumbosacral joint extends thereby elevating the hindquarters, and subsequently, the hip joints will also extend to elevate the lower limbs [4,5]. Because extension of the hindquarters also takes place during semen collection on a phantom, it seems logical to focus on that part of the locomotor system when studying the possibility that semen collection and show jumping performance negatively influence each other.

Therefore, in this study, the biomechanics of the stallion during semen collection on a phantom were assessed. The hypothesis was that the range of motion (ROM) of the hindquarters, and in particular the degree of pelvic flexion and extension, during both the mounting phase (MP) and ejaculatory phase (EP) of semen collection was similar to that exhibited during (show) jumping.

2. Materials and Methods

2.1. Horses

Six adult warmblood stallions used regularly for semen collection and international level jumping or dressage were used in this study. They comprised three KWPN (Dutch Warmblood) horses, two Holstein horses, and one Westphalian horse, all kept at a single breeding station. The mean age (range) was 16.2 years (10–21), and the mean height (range) at the withers was 1.72 (1.70–1.74) m. The Animal Care and Ethics Committee

concluded that no approval was required to perform this study.

2.2. Experimental Design and Data Collection

Prior to each recording, the horses were kept indoors in their stables. Recordings were made on 3 separate days, with 3-day intervals. Six spherical skin markers (25 mm diameter) were attached to specific anatomic locations, which were identified by digital palpation, on the right-hand side of the body. The locations were the highest point of the withers; the tuber coxae; greater trochanter; lateral side of the stifle on the fibular head; lateral side of the tarsus on the distal end of the tibia; lateral side of the distal end of metatarsus III (Fig. 1).

A home-video camera (60 Hz, Apple iPhone 4s) was positioned perpendicular to the phantom, and the phantom was set at a fixed height and slope for all six stallions. For each recording, the stallion was guided toward the phantom and allowed contact with the head of a teaser mare; after achieving full erection, the stallion was allowed to mount the phantom and semen was collected into an artificial vagina. We started video recording just as the stallion started to mount the phantom and stopped after ejaculation when the stallion was dismounting; the different phases (mounting vs. ejaculation) were identified from the behavior of the stallion and confirmed by the semen collector; the markers were always placed by the same investigator (E.B.), in a manner shown previously to be reliable and reproducible [6].

2.3. Data Analysis

Using commercially available video processing software (MPEG Streamclip, version 1.9.3b8, Squared 5), the video recordings were converted into image sequences, with a recording frequency of 10 Hz (frames/s; [6]). The image sequences were analyzed using commercially available image-processing software (ImageJ, version 1.47, National

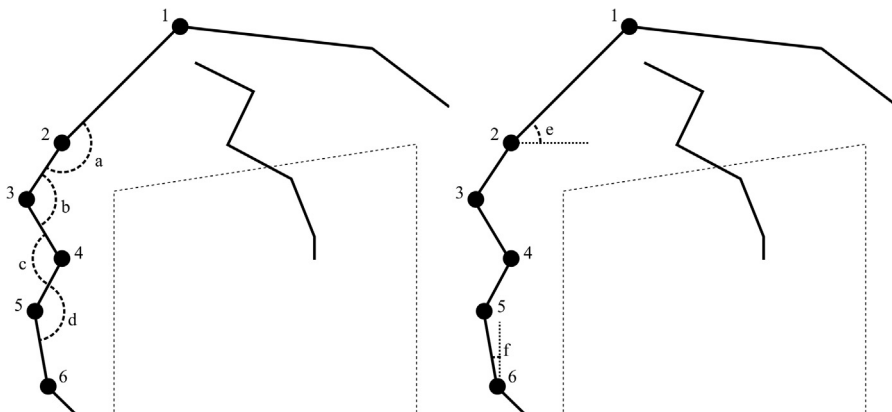


Fig. 1. Schematic illustration of the anatomic locations at which markers were attached to the horse. (1) highest point of the withers; (2) tuber coxae; (3) proximal femur; (4) proximal tibia; (5) distal tibia; (6) distal metatarsus III; and the six angles measured (a) pelvic flexion angle, (b) hip angle, (c) stifle angle, (d) tarsus angle, (e) body stance angle (deviation from horizontal), (f) hindlimb stance angle (deviation from vertical).

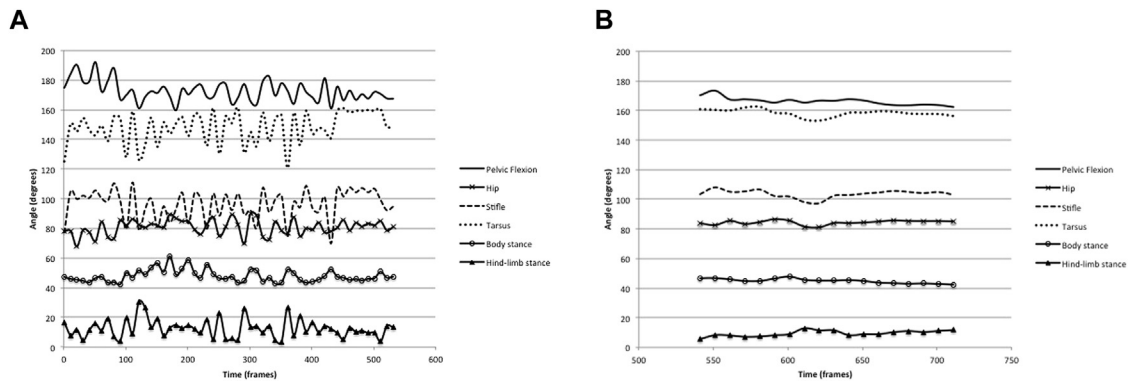


Fig. 2. (A) Typical example of how the six measured angles changed during the mounting phase. (B) Typical example of how the six measured angles changed during the ejaculation phase.

Institute of Health, USA). Using this software, a total of six angles (Fig. 1) were measured between the various skin markers during the MP and EP.

2.4. Statistical Analysis

Differences in joint angle and movement between the two phases of semen collection were compared using graphical representations of the data and paired t-tests, with $P < .05$ chosen to indicate statistically significant differences. Statistical analysis was performed using commercially available software SPSS (IBM).

3. Results

3.1. Comparison of Angles Within a Horse

In the coordinate system used in this study, the angle of the tarsus (on the flexor aspect) was significantly greater than that of the hip (i.e., it was more extended) and was also significantly greater than that of the stifle; the stifle angle was larger than the hip angle ($P < .05$). The body stance angle (deviation from horizontal) was significantly greater than the hind limb stance angle (deviation from vertical). Finally, the degree of pelvic flexion was greater than the angle of the tarsus (on the

flexor aspect). This helped to establish the relationships (angles) between the various body parts using the chosen marker set and associated coordinate system.

3.2. Comparison of MP and EP

A clear difference was found between the MP and EP, as shown by typical examples in Figs. 2A and 2B. The six measured angles fluctuated during the MP and tended to increase and decrease (extension and flexion) with a regular periodicity. During the EP, the fluctuations were reduced and the angles became more constant, reflecting reduced movement of the horse's hindquarters.

3.3. Relationship Between Pelvis and Back

The relationship between the pelvis and back differed during the two phases (Figs. 3A and 3B). During the MP, when the degree of pelvic flexion was smaller (i.e., flexed pelvis), the body stance was more upright. When the pelvic flexion angle increased (i.e., extension of the pelvis), the body stance became more horizontal. By contrast, during the EP, this relationship was reversed. The body stance was more upright when the pelvis was extended,

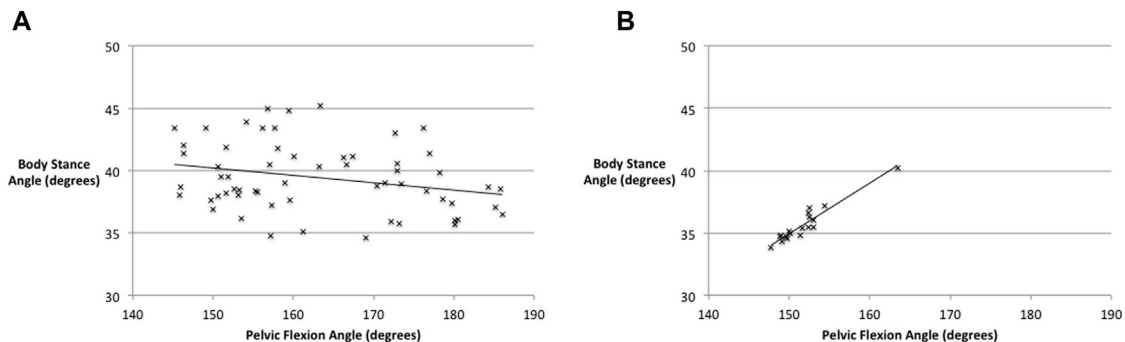


Fig. 3. (A) Graphical representation of the relationship between pelvic flexion and body stance during the mounting phase. (B) Graphical representation of the relationship between pelvic flexion and body stance during the ejaculation phase.

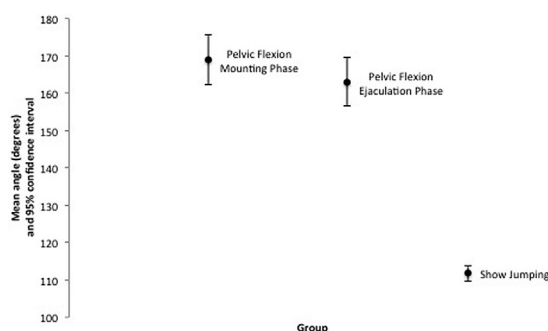


Fig. 4. The mean and 95% confidence intervals for the degree of pelvic flexion during the two phases of semen collection and hindlimb retroflexion during show jumping.

and the body stance was more horizontal when the pelvis was flexed. This can be explained by the way that stallions half stand during the MP but bring their forelegs back and their head and neck down onto the phantom during the EP.

3.4. Pelvic Flexion During Semen Collection Compared to Show Jumping

The ROM of the hindquarters during semen collection was subsequently compared to the ROM previously reported during show jumping, for the purpose of illustration [4]. Although the original data from jumping horses were not available, the mean pelvic angle during show jumping appears to be less than during semen collection; moreover, the confidence intervals (CI) during the MP and EP of semen collection were similar, whereas the CI during show jumping seems to be smaller (Fig. 4). In other words, the degree of pelvic flexion during both the MP and EP of semen collection was less (pelvis was more extended) than during show jumping, but the values recorded during semen collection were also more variable.

4. Discussion

The aim of this study was to assess the biomechanics of the stallion's hindquarters during semen collection on a phantom. In particular, the degree of pelvic flexion during both the MP and EP of semen collection was examined.

The hypothesis that the ROM of the hindquarters, in particular the degree of pelvic flexion and extension during

both the MP and EP of semen collection, would be similar to that exhibited during show jumping was not accepted. Rather, it was found that the ROM during semen collection was much larger and more variable. The reduced variability during jumping could in part be explained by the larger sample size used by Santamaría to determine the ROM.

The pelvis exhibited extreme extension and flexion during the MP, whereas during the EP, the pelvis was kept relatively flexed. The fluctuations in hip, stifle, tarsus, and hindlimb stance reflect alternate “stepping” with the hindlimbs during the MP.

The results indicate a clear difference between the MP and EP; in particular, the MP involves characteristic flexion and extension of the pelvis. It is unclear whether this extreme flexion and extension of the pelvis is a positive or negative aspect of the semen collection procedure or whether it would have a negative impact on a stallion's subsequent jumping capacity. It could be argued that extreme flexion imposes a different load on the musculoskeletal structures involved in pelvic rotation and may thereby interfere with the ability to extend the pelvis during show jumping. On the other hand, it could be suggested that stimulating an increased ROM in the pelvic region is beneficial because it generally improves the degree of flexibility.

During this study, additional qualitative observations were made. Some stallions had the tendency to mount the phantom without progressing to ejaculation but instead dismounting and starting again. Up to nine mounting attempts were necessary before semen collection was completed on some occasions; however, this process did not affect the ROM measurements during the final mount that was accompanied by ejaculation. The sudden pre-ejaculatory dismounting involved was, however, accompanied by twisting of the body and is not only potentially dangerous for the handler, but could also influence musculoskeletal structures of the horse's back and hindlimbs. Martin and McDonnell [7] and McDonnell [8] emphasize the importance of monitoring a stallion's comfort during breeding, where signs of discomfort may be reflected in the number, pattern, depth, rhythm, and strength of copulatory thrusts as well as restlessness of the hindlimbs [7,8].

In addition, the stallions tended to mount the phantom slightly to the left, perhaps positioning their body to account for the artificial vagina being held on that side of the phantom. The back of the horse can move in several planes, namely pelvic flexion, lateral bending, and axial rotation

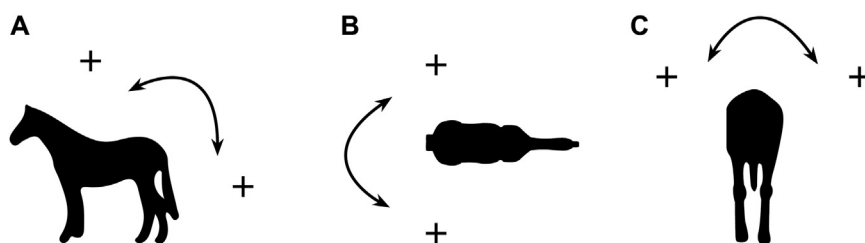


Fig. 5. The three planes of movement of the back. (A) Pelvic flexion: rotation around an axis perpendicular to the sagittal plane. (B) Lateral bending: rotation around the dorsoventral axis. (C) Axial rotation: rotation around the craniocaudal axis [6,9].

(Fig. 5; [6,9]). When the stallion's body is not positioned straight on the phantom, not only pelvic flexion but also lateral bending and axial rotation could be unbalanced, leading to asymmetrical loading of the hindlimbs. Martin et al [10] stress the value of correct positioning of the horse on the phantom, so that the back is not curved during pelvic thrusting [10] and thereby preventing exacerbation of any subclinical back and/or hindlimb pain that may have resulted from sporting performance at a high level.

5. Conclusions

There appears to be a clear difference in the biomechanics of the stallion's back and hindquarters between the MP and EP of semen collection. The pelvis shows hyperflexion and hyperextension, seemingly similar to excursions during show jumping, but which may impose a very different loading on musculoskeletal structures given that the animal is standing in a relatively fixed position. When asymmetric lateroflexion and/or axial rotation, as a result of the angle of approach to the phantom, are superimposed, these movements could exacerbate subclinical locomotor pain in the hindquarters initially induced by the demands of high-level sports performance. Nonetheless, for a complete picture, the outcome of this study would need to be combined with a clinical locomotor examination and subsequent analysis of show jumping performance, which could be realized using modern IMU sensor technology [11].

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