Morphological criteria influencing measured withers height in horses

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There are no conflicts of interest.

Abstract

Die Messung der Widerristhöhe bei Pferden ist ein wichtiges Identifikationskriterium und ein wesentlicher Bestandteil der Identifikationsangaben im Pass fast aller Pferderassen. Bei Ponys, die an Wettbewerben teilnehmen, ist die Messung der Widerristhöhe ein wichtiges Instrument zur Einstufung dieser Pferde, insbesondere in internationalen und nationalen Wettbewerbsklassen der FEI-Disziplinen. Das Verständnis der Messpraxis ist teilweise eingeschränkt und wird nicht immer ausreichend akzeptiert. In dieser Studie haben wir versucht, die Faktoren zu verstehen und zu analysieren, die diese Messung beeinflussen können. Es wurden zwanzig Pferde zweier verschiedener Rassen (Schweizer Warmblut und Freiberger) im Alter zwischen 3 und 4 Jahren verwendet, die der Schweizer Armee gehören. Die Messungen der Widerristhöhe wurden zweimal im Abstand von 14 Tagen von zwei erfahrenen Pferdetierärzten durchgeführt. Während jeder Messreihe wurden pro Tierarzt drei Messungen auf der linken und rechten Seite mit einem Widerristhöhenmesser mit Wasserwaage durchgeführt. Die Ergebnisse zeigen einen signifikanten Unterschied zwischen den Messungen auf der linken und rechten Seite (P = 0.01108). Es wurde beobachtet, dass die auf der linken Seite gemessene Widerristhöhe systematisch niedriger ist als die auf der rechten Seite gemessene (Korrelationskoeffizient = 0,2). Es gab keine Unterschiede zwischen den Messungen der beiden Tierärzte. Der Unterschied zwischen den in 14-tägigen Abständen durchgeführten Messungen war der Unterschied nach Bonferoni-Korrektur nicht mehr signifikant. Die Autoren weisen darauf hin, dass bei diesem Verfahren mehrere Fehlerquellen auftreten können. Sie schlagen eine alternative Messmethoden vor, etwa die Vermessung am Becken (Sakralhöcker), die unter Einsatz dreidimensionaler Bildgebungstechniken eine höhere Zuverlässigkeit aufweist.

Withers height measurement in equines is an important identification criterion and an integral part of the identification information in a passport for almost all horse breeds. In ponies that participate in competitions, withers height measurement is an important tool for categorising these equines, particularly in international and national competition classes in the FEI disciplines. The understanding of the measurement practice is sometimes limited and poorly accepted. In this study, we sought to understand and analyse the factors that may influence this measurement. Twenty horses of two different breeds (Swiss Warmblood and Franches-Montagnes horse) belonging to the Swiss Armed Forces and aged between 3 and 4 years were used. Height measurements at the withers were taken twice, with an interval of 14 days, and were performed by two experienced equine veterinarians. During each session, 3 measurements per veterinarian were taken on both the left and right sides using a measuring stick equipped with a level. The results obtained indicates a significant difference in measuring between the two sides (p=0.01108). It was observed that the height at the withers measured on the left is systematically lower than that measured on the right (correlation coefficient = 0.2). There were no differences in the measurements taken between the two veterinarians. The difference in measurements taken at 14-day intervals was also significant (p=0.019). The results were not influenced by angle measurements, particularly those of the hooves. The authors confirm that multiple sources of error can occur during this procedure and that an alternative solution such as measuring at the pelvis (sacral tuberosities) must be more reliable, even when using three-dimensional imaging techniques.

1. Introduction

Wither height is an important anatomical parameter in horses, not only for aesthetic evaluation but also for basic functional performance. Wither height is not only relevant for determining the height of a horse for identification purposes but also for determining if an equid is defined as a pony or a horse - the FEI defines a pony as measuring 148 cm or less without shoes or 149 cm with shoes (Pugh, 2017) [1a], [1b]. It is clear that accurate measurements are essential for ponies in FEI competitions, as a difference of just 1 cm can determine eligibility for future competition.

Wither height is measured at the highest point on the withers, dorsal to the spinous process of the fourth or fifth thoracic vertebrae (T4/T5) (Curtis, 2010) [2a], [2b]. Various factors, such as the time of day, exercise, transport, sedation, hydration status, and stress, can compromise the accuracy of wither height records (Van de Pol, 2007; Hickman, 1984) [3], [4a], [4b]. Recent studies have further supported these observations, emphasizing that posture during measurement and surface unevenness can significantly impact results (Wulf et al., 2020) [5]. Additionally, another author highlighted inconsistencies between manual and laser-based measurement techniques, underscoring the need for methodological standardization (Santschi et al., 2018) [6].

An important contribution to the understanding of morphometric correlations comes from a study that looked at standardized radiographs of ponies (Thieme, 2017) [7]. Based on standardized radiographs of 81 ponies (wither height: 81.5–148 cm), the authors' findings are clear: linear hoof measurements and wither height show strong correlations, while angular parameters are less informative. A regression model established reference values for a pony with a wither height of 120 cm, emphasizing the importance of objective anatomical markers in conformation assessment.

According to one author (Lama, 2007) [8], [9], three points are pivotal to the accuracy of wither height evaluation: anatomy, animal compliance, and measurement technique. From an anatomical perspective, it has often been accepted that the presence of asymmetry in many advanced mammals, with one side of the predominantly symmetrical bilateral body showing greater development than the other. Asymmetry refers to physical differences between the two sides of the body, such as differences in shape, size, bone dimensions, muscle growth, vascularisation and, most importantly, the nervous system, including the brain. Laterality, on the other hand, describes an individual's preference for using one side of the body for certain tasks, such as using one hand for writing in humans. Laterality indicates a functional preference; asymmetry refers to physical differences (Marques, 2024) [10], [11].

The presence of laterality has been recognized in various species, including humans and horses for a long time (Kuhnke, 2020; Farmer, Krueger and Byrne 2010) [12], [13], [14]. A recent investigation (McGreevy, 2022) [15] showed that equine laterality not only affects locomotion and behavior but may also influence anatomical development. Emerging studies suggest that variables like sex and mane direction may also affect lateral behaviour. For instance, a original study (Krüger et al., (2014) [16] and other behavioural analyses have shown that sensory laterality, like preferring the left eye during social interactions, is independent of sex (Krüger et al., (2020) [17]. The same authors indicate a link between mane side and lateral preferences. Mane orientation may correlate with motor laterality and asymmetrical loading in ridden horses, although direct evidence remains preliminary. However, these factors have not been explicitly investigated in relation to wither height asymmetry, presenting a novel angle for morphometric research.

Despite its importance, the effect of laterality on wither height measurements has not been satisfactorily investigated. This scientific project aims to establish whether the height of a horse at the withers varies depending on the side from which the measurement is taken, who is conducting the measurement, and when the measurement is taken. It is hypothesised that angular measurements and the distances between specific anatomical landmarks will significantly influence the measured height.

2. Materials and methods

Animals

The horses were provided by the Swiss Armed Forces: 10 Warmbloods and 10 Franches-Montagnes, aged between 3 and 4 years. All horses were housed either on pasture or in all-weather paddocks. The Warmblood horses were trained exclusively for riding, whereas the Franches-Montagnes were trained for riding, driving and pack work. The same handler performed the grooming. All grooming and measurement procedures took place in a room compliant with the FEI's regulations for measuring ponies and the horses were positioned as required.

Animal Welfare statement

All the data used for this study was collected during the year 2024. It fully complies with the Swiss legislation concerning the codes of ethical behaviour and animal protection.

Statement of informed consent

All horses belonged to the Swiss Armed Forces. They are aware and consented to inclusion of all gathered data in a scientific publication.

Study Design

The height at the withers was measured twice for each horse, with a 14-day interval between the two sessions. Before each measurement, specific anatomical landmarks were palpated, marked, and photographed. These reference points were used to assess repeatability and potential variation in measurement. They were then analysed using the software «My Measures» (The Appraisers, Inc., 2025) [18]. Landmarks were chosen based on their ease of palpation and were re-marked before each session. Each measurement was performed three times on each side by two different observers to assess inter-observer consistency.

Anatomical Landmark Marking

Height measurements were taken before marking five anatomical reference points with Tipp-Ex® correction fluid. This ensured consistency and facilitated data comparison. The reference points are as follows (see Figure 1):

- A: Highest point of the withers (dorsal spinous processes of the 4th–5th thoracic vertebrae)
- B: Highest point of the scapular cartilage
- C: Point of the pars caudalis of the greater trochanter of the humerus
- D: Lateral epicondyle of the humerus
- E: Point located at the metacarpophalangeal joint, adjacent to the sesamoid bone,
- F: Point located on the ground and perpendicular to A

In addition, two calibration points (Z) were marked exactly 10 cm apart (Figure 1) to serve as a reference scale within the My Measures software. Sex (mare or gelding) and mane orientation (left, right, or bilateral) were also documented for each horse.

Photographs

Photographs were taken using a camera mounted on a plastic tripod to minimize environmental movement. The camera was positioned at exactly 1 m from the horse and aligned to a point midway between landmarks B and C, and directly below point A. Two photographs were taken on each side. These images were used to measure the distances between landmarks via the «My Measures" software.

Distance and Angle Measurements

Using My Measures, the following linear distances were recorded:

- A to B
- B to C
- C to D
- D to E
- A to E

Two anatomical angles were also calculated:

- A1: The angle formed by the lines B–C and C–D

- A2: The angle formed by the lines C–D and D–E

Additionally, hoof angle A3 was measured using a level (mobile application) designed for angle measurement.

The calibration distance Z (10 cm) was also measured manually with a flexible tape measure to verify scale accuracy.

Withers Height Measurement

The two observers approached calmly and positioned the height stick so it remained out of the horse's field of vision until placement. The height stick was placed perpendicular to the ground and aligned with the highest point of the withers. The integrated level on the height stick ensured vertical accuracy. Each observer performed three height measurements per horse on each side – resulting in six measurements per horse.

Statistical analysis

The data analysis was performed using RStudio (version 2023.06.1; RStudio Team, 2023) [19] in combination with the R programming language (version 4.3.1; R Core Team, 2023) [20], which together provide a flexible environment for statistical computing. The dataset, originally

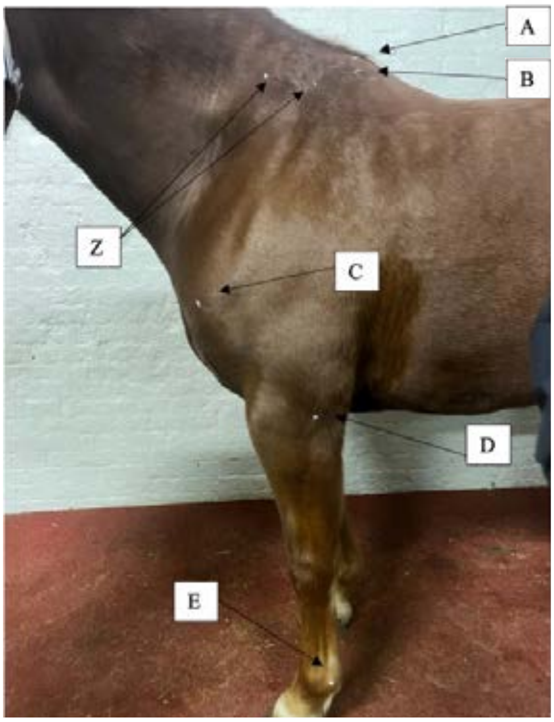

Figure 1: Marking anatomical points: own photograph. (Karol 2024)

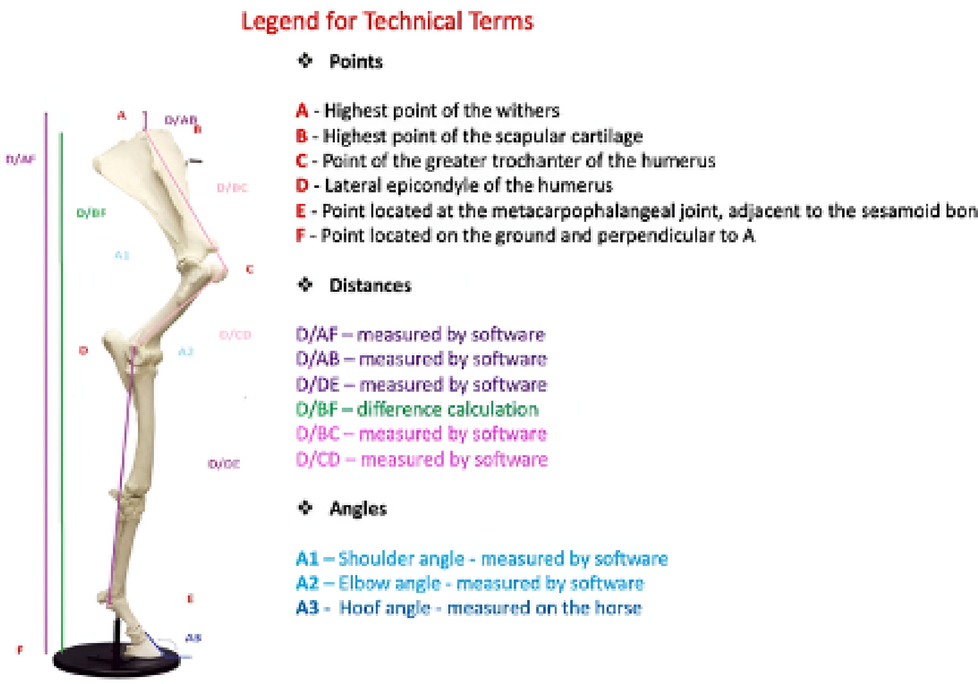

Figure 2: Measuring anatomical distances and foot angles: own illustration (Montavon & Karol 2024)

stored in a Microsoft Excel file, was imported into R and prepared for analysis using the dplyr and tidyr packages (Wickham, François, Henry, & Müller, (2023); Wickham & Henry, (2023) [21], [22]. These packages were used to organize the data by selecting relevant variables, renaming columns, handling missing values, and restructuring the data into a format suitable for analysis. To visualize the results, the ggplot2 package (Wickham, 2016) [23] was used. This tool allows for the creation of clear, customizable, and publication-quality plots that help to identify patterns and relationships in the data. Overall, this software setup made it easier to process, explore, and present the data in a way that supports clear interpretation of the results.

3. Results

The following section presents the statistical findings from the measurement of withers height in horses. We examine the influence of the measurement side, the person performing the measurement, the timing of the measurement, as well as specific angles and distances between anatomical reference points.

Influence of the Measurement Side on Withers Height

Each horse's withers height was measured from both the left and the right side during data collection. At each time point, three repeated measurements were taken by each measurer from each side. The mean of these three values was then calculated, resulting in one representative value per side, per time point, per measurer, and per horse.

A paired t-test was used to assess systematic differences between left and right side measurements. This test accounts for the paired nature of the data, as each left side measurement has a corresponding right side measurement for the same horse, time point, and measurer.

Results of the Paired t-Test:

- Mean withers height (left side): 159.21 cm

- Mean withers height (right side): 159.75 cm

- Mean difference (left − right): −0.54 cm

- p-value: 0.01108

The p-value is below the conventional threshold of 0.05, indicating a statistically significant difference between the two sides. However, it should be noted that no correction for multiple comparisons was applied at this stage. A Bonferroni correction will render this result non-significant if the number of statistical tests performed within the overall study is high enough.

When testing multiple hypotheses, the overall type I error rate increases if no adjustment is made. Maintaining a family-wise error rate at 5% often means reducing the significance level for each individual test. The Bonferroni correction is the most common method for this adjustment. It divides the alpha level by the number of comparisons. The current result is statistically significant, but the strength of this significance may be affected by the number and type of multiple comparisons conducted throughout the study.

Analysis of the Difference Between Left and Right Side Measurements

To explore the difference between measurements of the two sides further, the value measured from the left side was subtracted from the corresponding value on the right side for each horse, time point, and measurer.

The resulting values were consistently negative, indicating that measurements taken from the left side were consistently lower than those taken from the right. The following patterns were clearly observed in the data:

- A general trend towards negative values was observed across the dataset.

- In many horses, the side difference remained relatively stable across measurers and time points.

- Certain horses (e.g., H20) displayed higher values on the left side.

- In some cases (e.g., H17), values varied depending on the measurer.

- In a few cases (e.g., H16), fluctuations occurred between time points even within the same measurer.

The point-biserial correlation was calculated to quantify the association between measurement side and measured withers height. For this analysis, the side of measurement was encoded as a binary variable (left = 0, right = 1) and correlated with the continuous variable of withers height. The point-biserial correlation coefficient was (r): 0.2. The correlation coefficient was calculated based on all paired measurements across horses, time points, and measurers.

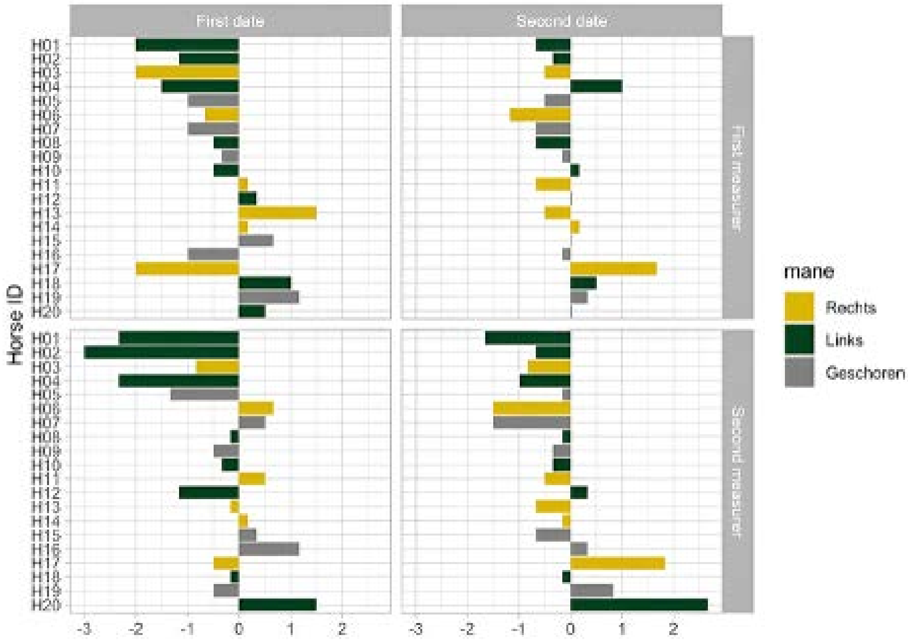

Figure 3: Difference in size between measurements taken from left and from right (in cm) (Gary Delalay 2024)

Influence of the Measurer on Withers Height

This section confirms the same approach as in the previous analysis concerning the side of measurement. It definitively shows whether the person conducting the measurement influences the values of withers height. For each measurement point, values from two different measurers were available. A paired t-test was used to assess the differences between the two measured values.

Results of the Paired t-test:

- t-value: −0.29625
- Degrees of freedom (df): 79
- p-value: 0.7678
- 95% confidence interval: [−0.1769; 0.1311]
- Mean difference: −0.0229 cm

The p-value is well above the conventional significance threshold of 0.05, indicating no statistically significant difference between the measurements taken by the two measurers.

Furthermore, the distribution of the differences between left and right-side measurements was plotted separately for each measurer. The first measurer showed less variation between sides compared to the second measurer. However, there was no clear directional bias for either measurer.

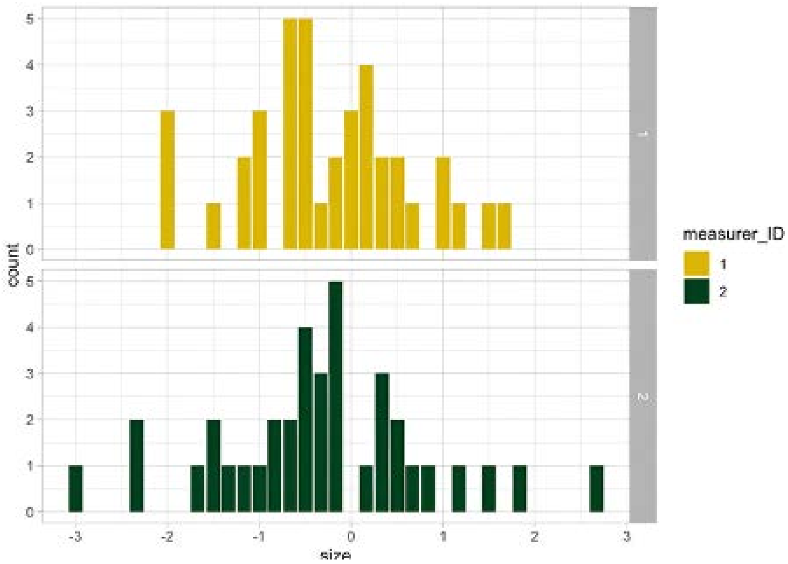

Figure 4: Statistic table 2 – The measurement data collected by the two measurer (Gary Delalay 2024)

Analysis of the Influence of the Date

To evaluate the repeatability of the wither height measurements over time, paired measurements were obtained from all horses at two time points within a 14-day apart. A paired t-test was performed to assess whether there was a statistically significant difference between the two measurement occasions. The analysis included 80 paired observations. The test result showed a statistically significant mean difference between the first and second measurement ($t = 2.394$, $df = 79$, $p = 0.019$). The calculated mean difference was 0.244 cm, with a 95% confidence interval ranging from 0.041 cm to 0.446 cm.

To further examine the relationship between measurement time, point of measurement and other variables, a Pearson's product-moment correlation was calculated between the asymmetry factor (AF2) and the second measurement time point. The analysis yielded a statistically significant negative correlation ($r = -0.181$, $t = -2.312$, $df = 158$, $p = 0.022$), with a 95% confidence interval of

-0.327 to -0.027. In addition, a point-biserial correlation was conducted to determine the strength of association between the categorical variable representing the time point and the continuous variable of measurement difference. This allowed for a further quantitative evaluation of the effect of measurement timing on wither height.

Influence of Angles A1, A2, and A3

Angles A1, A2, and A3 were measured at anatomically defined points on each horse and evaluated for their potential association with withers height. Linear regression models were constructed using these angles as independent variables and using withers height as the dependent variable. Statistical analysis was conducted using the R programming language (version 4.3.1) within the RStudio environment (version 2023.06.1). The significance of each variable was assessed based on p-values. For all three angles, the calculated p-values exceeded the threshold of 0.05, indicating that no statistically significant association between angles A1, A2, or A3 and withers height could be identified.

- p-values (A1, A2, A3): all > 0.05

Influence of the Distances Between Points A–E

The linear distances between anatomical reference points A, B, C, D, and E were recorded and included as predictor variables in linear regression models to assess their relationship with withers height. All statistical procedures were performed using R (version 4.3.1) in combination with RStudio (version 2023.06.1). For each measured distance, p-values were computed to evaluate significance. All distances yielded p-values greater than 0.05, indicating that none of the measured distances between points A–E showed a statistically significant association with withers height.

- p-values (all distances A–E): all > 0.05

4. Discussion

The present study shows that the side from which the withers height is measured has a significant influence on the outcome of the withers height measurement. Measurements taken from the left side of the horse were on average 0.54 cm lower than those taken from the right side. This difference was statistically significant (p=0.01108), though it may lose significance

Figure 5: Pictures from the measuring stick with level: own photograph (Karol 2024)

under conservative correction procedures such as the Bonferroni correction. However, the consistency of this effect across animals and repeated measurements suggests a systematic bias likely influenced by horse behaviour and handler interaction. Given this, the side of measurement should be carefully standardized and accounted for in future protocols.

Side specific differences in withers height

The results definitively showed a significant difference in withers height measurements taken from the left versus the right side. The mean difference was 0.54 cm, with measurements from the left consistently lower than those from the right. Such asymmetries may reflect not only behavioral conditioning but also underlying neuromuscular asymmetries developed through handling and training practices (McGreevy & Rogers, 2005) [27].

It is well established that the left side of the horse is used more frequently for tasks such as leading, saddling, grooming, and veterinary interventions. This convention, originating from historical military practices (Hall & Heleski, 2007) [24], continues to influence modern equine handling. Studies (Krüger et al., 2008 and 2014) [25], [26] demonstrate that horses develop individual lateral preferences (motor and sensory), which are shaped by repeated exposure to one-sided handling. One author (Krüger, 2008) [25] showed that horses often prefer one side during human approach or intra-herd interaction, indicative of hemispheric specialization. This is supported by findings that the left eye (processed by the right hemisphere) is preferentially used for unfamiliar or threatening stimuli (McGreevy & Rogers, 2005) [27]. Another author (Rogers, 2010) [28] further elaborates that such cerebral lateralization is widespread in vertebrates and can manifest in measurable behavioral asymmetries.

Human handedness also plays a role. Most handlers are right handed and may unconsciously perform tasks more precisely on the right side. According to a further author (Hall and Heleski, 2007) [24], right-handedness in humans corresponds with a preference for leading and standing on the horse's left, possibly reinforcing side specific interactions.

Beyond these behavioural and anatomical influences, the horse's training status also significantly impacts the measured withers height. As highlighted in a study (Stammer, 2017) [30] the muscle tone and posture developed through consistent training affect the horse's frame and elevation. Well-trained horses tend to carry themselves with more engagement and positive tension along the topline, often resulting in a higher measured withers height. In contrast, less conditioned horses typically show a more relaxed posture, which can lead to lower measurements. This underlines the importance of accounting for the horse's fitness and training when interpreting morphometric data.

Effect of the person measuring

Although measurement is subject to individual interpretation, this study did not reveal significant differences between the two examiners. It is important to mention at this point that both equine practitioners who took the measurements were right-handed. The use of a level-mounted measuring stick helped to reduce variation. All measurements were taken under consistent conditions in a controlled indoor setting.

One author (Krüger et al., 2016) [26] emphasize that environmental uniformity reduces cognitive load and behavioral distractions in horses, leading to more stable postural outcomes. Another author (Visser et al., 2001) [32] also report that horses habituate to standard procedures more quickly in consistent environments, which improves measurement reliability.

Although minor subjectivity may exist in interpreting the anatomical landmark (highest point of the withers), this appears manageable through training and repetition. Some authors (McGreevy and McLean, 2007) [33] underscore the value of standardised procedures and repeated familiarisation to reduce variability in equine assessments.

Effect of measurement time points

A small but statistically significant difference was observed between the first and second measurement taken 14 days apart (−0.244 cm, $p = 0.019$). The second measurement was lower. However, after applying the Bonferroni correction for multiple comparisons, this difference no longer reached statistical significance. This result must be interpreted with caution. It is more a potential tendency than a conclusive or robust effect. This difference most likely reflects postural relaxation due to habituation. It was confirmed that horses show reduced tension in repeated testing situations, which can influence muscle tone and posture (Krüger, 2011) [34].

Other authors found that repeated gentle handling reduced physiological stress markers in horses, which may translate into a more neutral, lower posture during follow-up measurements. Future studies should incorporate video based posture scoring or three dimensional monitoring systems to better account for postural drift (Hausberger et al., 2008) [35].

Influence of angular measurements (A1–A3)

No significant correlation was found between the measured angles (A1, A2, A3) and withers height. Anatomically, this may be due to the unique musculoskeletal structure (shoulder synsarcosis) of the equine forelimb. Without a clavicle, the horse's scapula is attached to the trunk solely through muscular structures, allowing for a wide range of compensatory mobility (Schurmann et al., 2004) [36].

This anatomical arrangement allows for substantial variability in scapular positioning and angle without necessarily altering the vertical height of the withers. Horses can therefore compensate for changes in joint angle through muscular adjustments, which makes linear or angular projections into a vertical frame of reference (such as height) inherently unreliable.

Furthermore, the muscular control of the shoulder and thoracic sling is not only dynamic but also influenced by external factors such as tension, learned movement patterns, and asymmetrical loading. As noted in Applied Equine Nutrition and Training (Lindner, 2011) [38], the thoracic sling musculature plays a vital role in suspension and elevation of the thorax between the forelimbs, meaning that even small variations in muscle tone or weight distribution can mask or override geometric joint relationships.

According to other authors (McGreevy and McLean, 2010) [29], many postural adaptations in domestic horses stem from training and handling-induced asymmetries, which can alter the way a horse carries weight through the forehand, independently of static joint angles. Such findings underscore the need for caution when interpreting morphometric data solely through angular measures.

Interestingly, no correlation was found between the measured joint angles and the position of the hoof or distal phalanx. This was unexpected, as hoof ground interaction and limb alignment are generally assumed to influence vertical body metrics like withers height. It appears that the hoof maintained a relatively stable position between measurements, despite minor variations in proximal limb angles. One possible explanation is that the horses' compensatory posture maintained ground contact symmetry, regardless of angular deviations.

Another factor to consider is hoof growth during the two-week period between measurements. Although hoof wall growth averages 6–10 mm per month (Curtis, 2010; Pugh, 2017) [1a], [1b], [2a], [2b], its apparent lack of influence on height measurements suggests either regular natural wear, recent trimming, or that any increase in height was insufficient to affect the measurement outcome. As already noted (Lama, 2007) [8], [9]; (Van de Pol and van Oldruitborgh.Oosterbaan, 2007) [3], even small changes in sole depth or hoof balance can subtly affect body posture. However, these effects may have been masked in this study by stable ground conditions and consistent handling.

Distance measurement and withers height

No significant associations were identified between the linear distances (A–E) and withers height. Although anatomical marking with Tipp-Ex® was practical, the precision was insufficient to ensure fully repeatable spatial points. Subtle reactions of the horse during marking may have affected position or muscle tone (Krüger et al., 2020) [17]. This is consistent with other findings (van Weeren and Barneveld, 1987) [37], who demonstrated that skin displacement relative to underlying bone during movement can cause significant errors in marker-based measurements, highlighting the inherent imprecision of superficial skin markers. Thus, the points marked and measured in this study likely suffered from such inaccuracies.

In this context, another study (Stover, 2018) [31] highlights that cannon bone length in racehorses is closely correlated with withers height and thus plays a significant role in the overall conformation of the horse. Since withers height is commonly used to assess size and performance potential, considering cannon bone length is important, as it influences limb biomechanics and the distribution of mechanical stress.

Measurements from digital photographs proved helpful but lacked a standardised camera position and perspective correction. Other authors (Fiske and Potter, 2014) [39] caution that photogrammetric methods require rigorous control over camera angle and subject orientation to avoid measurement distortion. One author (Müller et al., 2020) [40] recommend the use of calibrated stereo-photogrammetry or structured light scanning for improved metric accuracy.

In future studies, the use of markerless motion capture (e.g., DeepLabCut or Kinect) could improve reproducibility and eliminate the need for physical contact. One author (Bishop et al., 2022) [41] shows that modern machine learning-based tracking systems can reliably detect equine landmarks in 3D without markers.

Methodological Considerations and Outlook

The results of this study definitively show that morphometric measurements in horses, even when standardized, are influenced by behaviour, perception and technique. It is clear that the measurement side is the most significant influencing factor, and ethological explanations support this (Krüger et al., 2011) [25]. The findings further support and emphasis on the integration of learning theory and ethology into equine management and research design (McGreevy and McLean, 2010) [29]. The good reproducibility under consistent environmental and methodological conditions is encouraging, although temporal repetition will always introduce minor deviations.

From a practical standpoint, it is essential to standardise the measurement side consistently and document this in official height assessments. Investigation of individual laterality in horses is vital. Simple eye preference tests must be used to help interpret behavioural and measurement related deviations.

Exploration of alternative anatomical landmarks for morphometric measurements is a promising approach to improve accuracy and reproducibility in equine conformation analysis. The sacral tuberosity, as part of the pelvic skeleton, offers a structurally fixed reference point that, unlike the withers, is not subject to the dynamic variability introduced by the thoracic muscular sling. Preliminary scientific literature suggests that measurements or angular relationships originating from the pelvis may provide a more stable and reproducible foundation for morphometric assessments (Holmström, 2000) [42]. In contrast to the withers, which are influenced by muscular compensations in the shoulder girdle, the sacral tuberosities may serve as a more anatomically reliable landmark for precise measurements. This approach could open promising new avenues for biomechanically informed assessments of equine conformation and functional movement. Another consideration for future research is the implementation of advanced measurement technologies. Digital 3D scanning, motion capture, and other imaging-based techniques could offer greater objectivity and repeatability, especially relevant in clinical or breeding contexts where decisions hinge on millimetric precision.

5. Conclusion

This study provides a valuable contribution to understanding the relationship between morphometric parameters and withers height in horses. The study design was methodologically sound, incorporating standardized measurements across a heterogeneous population. Although the sample size was limited, making it difficult to draw statistically robust conclusions, meaningful tendencies were observed, particularly regarding the influence of specific angular parameters and the limitations of conventional measurement techniques. No significant breed effect was found within this group of horses. However, such differences may become more apparent with larger and more breed-specific sample sizes and should be a focus in future research.

One of the central findings of this study is the potential for measurement error associated with using the traditional measuring stick to determine withers height. Despite its widespread use, this method is susceptible to multiple internal and external influencing factors, such as ground conditions, posture, muscle tone, and handler variability. This issue becomes especially critical in cases where measurement thresholds carry regulatory or classificatory importance, such as the formal distinction between ponies and horses based on a difference of just one centimeter, underscoring the need for objective and highly reproducible measurement techniques.

In summary, this study demonstrates that even seemingly straightforward measurements, such as withers height, are subject to a complex array of influencing factors. The findings emphasize the importance of careful methodological choices, consideration of fixed anatomical landmarks, awareness of training-related functional changes, and adoption of modern measurement technologies. Future research should include expanding sample sizes, exploring alternative morphometric reference points, and integrating biomechanical and technological advancements. This will establish a more reliable framework for equine conformational assessment.

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Agenda 2026 – Nationale und internationale militärmedizinische Veranstaltungen / Kongresse

Veranstaltung	Ort	Datum
Jahrestagung 2026 der ÖGWMPh	*Wals-Siezenheim (A)*	*10. - 11.09.2026*
Internationale Tagung IT 2026 – SGOS	*Spiez (CH)*	*19.09.2026*
57. Jahreskongress der DGWMP e. V.	*Pappenburg (D)*	*08. - 10.10.2026*
46th ICMM World Congress of Military Medicine	*Abu Dhabi (VAE)*	*09. - 13.11.2026*
Combat Medical Care (CMC) Conference	*Paris (F)*	*19. - 20.11.2026*

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