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The Immediate Effect of Pole Work and Kinesiotape on Engagement of Rectus Abdominis and Longissimus Dorsi Activity, Pelvic Symmetry, and Kinematics in Horses

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Abstract

This study investigated the acute effects of ground poles and abdominal kinesiotaping (KT) on rectus abdominis (RA) and longissimus dorsi (LD) muscle activity, pelvic symmetry, and selected kinematic variables in eleven horses trotting in hand. Four conditions were evaluated: control, poles, KT, and combined KT with poles. Surface electromyography quantified muscle activity, inertial sensors assessed pelvic symmetry, and two-dimensional video analysis measured limb protraction and lumbosacral (LS) angle. Peak RA activity was significantly greater during poles and poles with KT compared with KT alone ($P \leq 0.003$), although average RA activity did not differ between conditions. LS angle was reduced during poles at forelimb midstance ($P = 0.035$) and at maximal hindlimb protraction ($P \leq 0.023$). Hindlimb protraction decreased in pole conditions ($P < 0.001$). No significant effects were observed for LD activity or pelvic symmetry. These findings indicate that pole exercise influences abdominal muscle activation and lumbosacral kinematics during trot. Kinesiotaping alone did not significantly alter muscle activity or kinematics. The magnitude and clinical relevance of observed changes were modest, and the potential influence of speed cannot be excluded. Further controlled studies incorporating three-dimensional kinematics and velocity measurement are warranted.

Keywords

Cavaletti; core; biomechanics; strengthening; taping

1. Introduction

Core strength is vitally important for maintaining effective locomotion, with evidence that core function correlates significantly with equine performance. In accordance with the "bow and string theory," epaxial and hypaxial muscles, such as *M. longissimus dorsi* (LD) and *M. rectus abdominis* (RA), counteract ground reaction forces (GRF) and stabilize the vertebral column with gait progression [**1–6**]. Since the strength of the muscular chain depends on its weakest link, it is vital to understand its function and explore strengthening techniques. Pole exercise is commonly used to encourage increased limb flexion and trunk engagement, whereas kinesiotaping is proposed to modulate neuromuscular activation via cutaneous stimulation. Although both interventions are independently used in rehabilitation settings, their combined acute effects on trunk muscle activity and lumbosacral kinematics have not been investigated. If kinesiotaping (KT) enhances abdominal activation, it may potentiate the mechanical demands imposed by poles. Conversely, its effect may be negligible when a mechanical stimulus is already present.

Due to the scarce scientific evidence on muscular activity during movements for rehabilitation [**7**,**8**] and the challenge of targeting an isolated set of muscles in the horse, global trunk-strengthening approaches are favored [9]. These often combine the use of various training aids, including Pessoa and poles [10,11]. Previous research [12] has found that the increase in LD activity over ground poles was not significant bilaterally, possibly highlighting the role of LD in lateral bending [13]. The same study reported activity of RA when walking and trotting over ground poles. Similarly, an increase in RA activity while trotting over poles using surface electromyography (sEMG) [14] was found.

The use of elastic bands is becoming very popular in rehabilitation settings. These bands aim to encourage hindlimb engagement and support recruitment of RA [12]. Similar to the abdominal band, stimulation of mechanoreceptors using KT is beginning to attract scientific interest, but its effects require further investigation [15–17].

Kinesio taping is thought to affect five systems: skin by decompression; fascia by redirecting movement; muscle via function optimization; lymphatic system through fluid redirection; and joints via proprioceptive awareness and muscle control [18]. The effects on kinematics and muscular activity have been minimally investigated in the equine sample. Still, the rich innervation of equine sensory receptors may account for effects across multiple layers [16,18] and consequently affect neuromuscular activity [18,19]. KT may be beneficial in abdominal engagement through the response from *M. cutaneus trunci* and its fascial connections with the underlying musculature [20]. However, only two studies have thus far implemented abdominal taping. A previous KT study [15] examined its effect when applied to the abdomen with no stretch, on the kinematics of the thoracolumbar spine in eight trotting horses using video analysis. Although no significant change in kinematics was observed, the activity of taped muscles was not measured. Abdominal KT increases longitudinal activity, decreases stride frequency, and thus potentially lengthens the stride [16]. The researchers explained this as a hypothetical increase in eccentric abdominal contractions during the stance phase, resulting in increased lumbosacral (LS) flexion, which provided the rationale for examining LS kinematics in the present study.

Furthermore, LS flexion was found to correspond with hindlimb protraction [6], which was also associated with desirable core and hindlimb engagement [21]. Lastly, trotting over poles increased flexion in all joints, consequently affecting protraction and retraction of both the forelimbs and hindlimbs, making it a relevant parameter for the current study [22].

This study investigated the effect of poles and KT applied to the abdomen on the LD and RA activity, LS angle, pelvic symmetry, and forelimb and hindlimb protraction and retraction angles. It was hypothesized that (1) poles would increase RA and LD activation and improve kinematics; (2) kinesiotaping would independently increase RA and LD activation, and kinematic parameters would be improved; and (3) combined application would produce summative effects.

2. Methodology

This study was designed and reported in accordance with the ARRIVE 2.0 Essential 10 guidelines [23] to ensure transparent and reproducible animal research.

2.1. Ethical Statement

The current study was approved by the Ethical Committee at Writtle University College (number: 98379136/2023). The study was carried out in accordance with guidance on the operation of the Animals (Scientific Procedures) Act 1986 and associated guidelines. The welfare of all animals was monitored according to a strict protocol, and any distress or decline in condition would result in exclusion from the experiment and appropriate veterinary attention. Fresh water for horses was provided throughout the data collection. Written consent was obtained from all owners of the horses participating in the study.

2.2. Horses

Eleven school horses (seven geldings and four mares of various breeds in light- to medium-work) were used for the study; mean ± SD age was 12 ± 4.5 years, and height at the withers was 156 ± 4.5 cm. The selection criteria excluded horses with a history of back pain/pathologies or with signs of pain and lameness; young horses; and horses not trained or unable to perform pole work. The sample size was calculated using the resource equation approach and power analysis. The sample size of eleven horses was deemed sufficient in similar published studies assessing sEMG in horses performing therapeutic exercises, which achieved adequate statistical discrimination with a range of four to six horses [12,24]. Assuming the methods differ slightly in their interventions and outcomes, with estimates differing by 10%, with Type I and Type II errors of 0.05 and 0.20, respectively, using the Bland-Altman test, we estimated that a sample size of between 5 and 12 horses was needed (MedCalc® Statistical Software version 20.115). Due to the extent of this study, a larger number of horses was chosen to account for possible equipment failures and to enable comparison with preceding studies [16]. The study cohort was standardized by selecting riding school horses in regular, light- to medium-work prior to data collection, which ensured a consistent fitness level and a moderate body condition score. These inclusion criteria controlled for variations in subcutaneous adipose tissue and muscle hypertrophy that can affect sEMG signals. Borderline BCS, muscular atrophy, or prominent asymmetry were factors that led to exclusion from the study, as well as any signs of lameness or underlying health condition during the screening process by a veterinary professional. The breed composition consisted primarily of Warmbloods, with a Thoroughbred, a Paint Horse, and a draft-cross, which ensured the results were representative of the general school horse amateur riding population.

2.3. Experimental Setup

Five wooden poles (10 cm cross-section, 1.2 m long) spaced at 120 cm ± 5 cm apart were placed perpendicularly to the long axis of a harrowed arena with a soft synthetic surface [12]. Pole spacing was adjusted by ~5 cm to accommodate the individual horse [12]. The high-speed camera, set to record at 240 fps, was positioned 8 m away from the trot-up area.

All horses were fitted with their usual bridle (two with a Micklem bridle, eight with an English snaffle bridle with a cavesson noseband without flash, and one with a flash). Horses were warmed up for 10 minutes (8 minutes of walking, 2 minutes of trot evenly on each rein, including walking and trotting over flat poles to habituate them to the exercise). For all conditions, horses were fitted with inertial measurement units (IMUs), sEMG electrodes, and reflective markers. For the tape condition, KT was applied as per [**16**]. Horses were trotted in hand from the left side in a marked straight line at their natural, consistent speed. The same handler was used to ensure consistency. Five successful trials were retained for data analysis for each horse in each condition. Data were not collected if the horse lost straightness or made an obvious gait alternation, and trials were deemed successful only if the horse stepped over the poles cleanly with a consistent speed and rhythm. The randomized conditions were:

(1) Without kinesiotape, straight line.
(2) Without kinesiotape, straight line over ground poles.
(3) With kinesiotape, straight line.
(4) With kinesiotape, straight line over the ground poles.

2.4. Kinesiotape Application

The targeted muscles were the RA and the obliquus externus abdominis (OEA) [**16**]. Marks were drawn bilaterally at the following anatomical locations: paralumbar fossa (ventrally to the tuber coxae); behind the girth at the level of the olecranon to tape the RA; further on, at the caudal ends of *M. pectoralis ascendens*; and on the ventral midline at the level of the 18th rib to tape the OEA.

Six-cm-wide pieces of adhesive KT (Vetkin, THYSOL Group B.V., Enschede, NL) were attached with ~25% stretch in the direction of the muscle fibers (**Figure 1**). The ends of the tape were attached without stretch to the marked point on the skin for better adhesion [**16**].

Figure 1: Tape application at 25% stretch (ventral view).

2.5. Kinematics Data Collection and Analysis

Six 3D, 30 mm diameter spherical reflective markers were secured using double-sided adhesive tape. For limb kinematics, markers were placed on the scapular spine tuberosity, the ventral border of the tuber coxae, and the mid-lateral aspect of the forelimb and hindlimb coronary bands. For LS kinematics, markers were placed at L6 and the greater trochanter of the femur, creating an angle with the highest point of the withers [**25**]. Before data analysis, calibration was performed in the motion analysis software using a video of horizontal and vertical lines. Calibration was performed prior to each data collection session using a standardized one-meter reference object. Although formal intra- and inter-session calibration reliability testing was not conducted, consistent camera positioning and environmental conditions were maintained.

Horses were recorded perpendicular to a single high-speed video camera mounted in a level position on a tripod (determined by a tubular spirit level), approximately 8 m from the horse, with one LED spotlight (500 W) to illuminate the reflective markers. The camera collected data at 240 Hz (resolution: 1,334 × 750 pixels, 720p HD), with a field of view that captured at least one full stride during trot.

Motion analysis software (Quintic Biomechanics v.34, Quintic Consultancy Ltd., Birmingham, UK) was used to analyze each video. The forelimb protraction and retraction angles were determined as vertical angles using markers on the scapular spine and the coronet band at the maximal points of protraction and retraction (**Figure 2**). The hindlimb protraction and retraction angles were determined by the tuber coxae and hindlimb coronet band at maximal hindlimb protraction and maximal hindlimb retraction. The greater trochanter, L6, and the highest point of the withers defined the LS angle. To reduce within-horse variability, measurements from three strides per trial and horse were averaged. Lumbosacral angulation was measured at four points of the stride [**25**]: forelimb midstance, hindlimb protraction, hindlimb midstance, and hindlimb retraction. Midstance was identified as the metacarpus/metatarsus being perpendicular to the ground [**26**].

2.6. Surface Electromyography (sEMG) Data Collection and Analysis

Muscle activity data collection and analysis followed the methodology described previously [**27**]. Surface electromyographic signals were acquired using a dual-channel sEMG system (Neurotrac MyoPlus 2 Pro, Verity Medical Ltd., Hampshire, UK). The device operated over a continuous amplitude range of 0–2000 μV root mean square (RMS) within a frequency band of 2–100 Hz, with pulse widths of 50–450 μs and a sensitivity of 0.1 μV RMS (4% accuracy; readings ± 0.3 mV at 200 Hz). The sEMG equipment used utilizes a fixed internal gain with a wide band-pass filter of 18 fHz to 370 Hz (for readings below 235 μV) or 10 Hz to 370 Hz (for readings above 235 μV). These parameters align with sEMG protocols previously reported in equine studies [**27**]. A 50 Hz notch filter and a high common-mode rejection ratio (130 dB) were employed to minimize environmental electrical noise and motion artifacts.

Manufacturer-supplied software (Neurotrac, Verity Medical Ltd., Hampshire, UK) was used to quantify activity in the left rectus abdominis (RA) and left lumbar longissimus dorsi (LD).

For electrode placement, hair was clipped over the lumbar region of the left LD (between L3 and L4) and caudal to the sternum for the left RA. Hair was removed from each site using clippers (No. 40 clipper blade) [**28**], and then the skin was prepared with surgical spirit to remove grease and debris and optimize electrode contact. All clipping was performed by the same investigator (AS) to ensure consistency among horses. A pair of pre-gelled electrodes (50 × 50 mm) was positioned 5 cm lateral to the spine at the left lumbar level (L3–L4). A second pair was placed 2 cm lateral to the linea alba, caudal to the sternum, over the left RA belly. The inter-electrode distance was 1 cm, which lies within the range reported in previous equine sEMG studies. A reference electrode was positioned over the left tuber coxae. Peak and mean muscle activity (µV) were extracted for each condition (**Figure 3**).

Raw sEMG signals were differentially amplified with a common-mode rejection ratio of 130 dB and processed with band-pass filters of wide (18 ± 4 Hz cut-off) and narrow (370 ± 10 Hz cut-off) bandwidths, as well as a 50 Hz notch filter. Outcome variables comprised the average rectified value (ARV) and peak sEMG for each muscle under all conditions, with exercise duration used as the temporal domain.

Outliers in ARV were identified and excluded using thresholds set at two standard deviations above or below the mean ARV for each horse, muscle, and condition, following the approach described in equine sEMG research [**29**]. For peak sEMG, outliers in the baseline recordings before normalization were detected and subsequently removed. Signals were normalized to muscle activity obtained while the horse stood square, enabling comparison with values recorded during exercise.

2.7. Pelvic Symmetry Data Collection and Analysis

Pelvic symmetry data were collected and analyzed in accordance with the protocol described in equine research [**30**]. A commercially available inertial sensor system (Equinosis Q Lameness Locator, Missouri, USA) comprising three sensors (3.8 × 2.5 × 1.3 cm; mass 30 g) was used. Sensors were secured to predefined anatomical landmarks following the manufacturer's guidelines: the poll (head bumper), the midline between the tubera sacrale (pelvic mount with adhesive bandage), and the dorsal aspect of the right forelimb pastern (limb strap).

Data were sampled digitally at 200 Hz in real time and processed using proprietary software supplied by the manufacturer (Equinosis Q Lameness Locator, Missouri, USA). Signals from the pelvic and poll accelerometers were analyzed using a custom error-correcting double-integration method, while the right forelimb gyroscope signal was used to determine stride segmentation. Uniaxial acceleration data from the pelvic sensors were converted into displacement traces, from which two maxima and two minima were identified per stride.

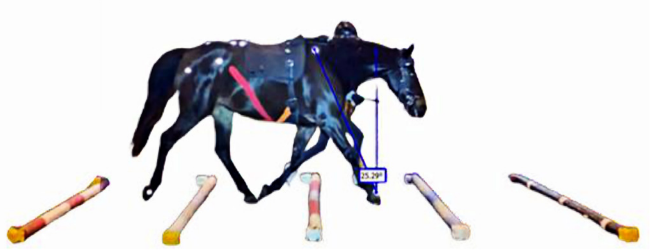

Figure 2: Data collection field with conditions "tape and poles" showing the angle from the vertical using the spine of scapula and coronet band markers to determine maximal forelimb protraction.

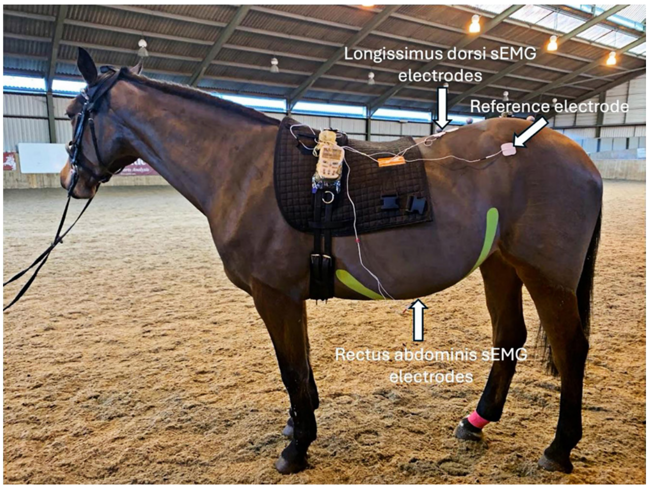

Figure 3: Positioning of sEMG electrodes (wires visible).

For each stride, the difference in minimum pelvic height between left and right stance phases (PDmin) and the difference in maximum pelvic height following left and right stance phases (PDmax) were calculated. Values exceeding a threshold of ±3 mm were interpreted as asymmetry; positive values indicated right hindlimb asymmetry, and negative values indicated left hindlimb asymmetry. To quantify pelvic asymmetry independent of direction, PDmax and PDmin values associated with the left hindlimb were converted to absolute (positive) values to permit direct comparison with right hindlimb measurements.

2.8. Statistical Analysis

Following analysis of the sEMG signals, all data were recorded in Microsoft Excel spreadsheets (Microsoft Excel Office 365, Redmond, Washington, USA) and transferred to Jamovi (version 2.6) for further statistical analysis. The Shapiro-Wilk test was used to determine normality. A one-way repeated-measures ANOVA test was used for normally distributed data with Greenhouse-Geisser (ε) correction when data violated the assumption of sphericity on Mauchley's test, and a Friedman's test was used for non-normally distributed data to discover any significant differences between conditions. Significance was established at $P < 0.05$. For each significant finding, post hoc analysis with a Tukey correction for repeated-measures ANOVA and Durbin-Conover for Friedman's test was performed to determine pairwise differences between conditions. For parametric tests, data are presented as mean ± standard deviation, and for non-parametric tests, data are presented as median (Mdn).

3. Results

Full sets of data were collected for all horses with the exception of average and peak activities for LD for two horses, which were excluded from the sEMG analysis due to inconsistency in readings. Parametric data are reported as the mean ± standard deviation, and non-parametric data are presented as the median (IQR Q1, Q3).

3.1. LD and RA Muscular Activity

The average activity of RA increased from Mdn = 44.36 µV (IQR 28.6, 107) with no intervention to Mdn = 62.96 µV (IQR 46.9, 104) with tape and poles, then to Mdn = 69.30 µV (IQR 42.1, 103) with poles only, and finally to Mdn = 75.56 µV (IQR 31.9, 170) with tape only; however, the differences were not statistically significant ($\chi^2(3) = 1.36$, $P = 0.714$). On the contrary, there was a significant difference in the peak activity of RA between conditions ($\chi^2(3) = 12.40$, $P = 0.006$). In the pairwise comparisons, there was a statistically significant increase with poles only (Mdn = 529 µV (IQR 330, 623)) and tape with poles (Mdn = 498 µV (IQR 362, 594)) compared with tape only (Mdn = 271 µV (IQR 166, 542)) ($P < 0.001$ and $P = 0.003$, respectively) (**Figure 4**).

Neither the average ($\chi^2(3) = 2.73$, $P = 0.435$), nor the peak activity ($F(3,24) = 0.155$, $P = 0.926$, $\eta^2p = 0.019$) of LD was statistically significantly different under different interventions.

3.2. Lumbosacral Angle

Lumbosacral angulation was measured at four points of the stride, from which a statistically significant difference was found at forelimb midstance and hindlimb protraction (**Figure 5**). LS angle at forelimb midstance was significantly different between conditions ($F(3,30) = 4.27$, $P = 0.013$, $\eta^2p = 0.299$). LS angle at forelimb midstance was significantly decreased with poles (147 ± 6.05°) when compared with no intervention (150 ± 5.59°) (−2.93° (95% CI, −3.82° to −2.04°), $P = 0.035$). LS angle at maximal hindlimb protraction was statistically significantly different between conditions ($F(3,30) = 7.88$, $P < 0.001$, $\eta^2p = 0.441$). It decreased with poles (146 ± 5.67°) and poles and tape (145 ± 5.16°) when compared with no intervention (149 ± 5.38°) ((−2.91° (95% CI, −3.74° to −2.09°), $P = 0.023$) and (−3.58° (95% CI, −4.40° to −2.76°), $P = 0.006$), respectively). Neither the LS angle at hindlimb midstance ($F(1.86,18.62) = 3.28$, $P = 0.063$, $\eta^2p = 0.247$) nor at maximal hindlimb retraction ($F(3,30) = 0.792$, $P = 0.508$, $\eta^2p = 0.073$) was statistically significant with different interventions.

3.3. Pelvic Symmetry

No statistically significant difference was found for both the pelvis difference minima (PD_{min}) ($F(3,30) = 0.314$, $P = 0.815$, $\eta^2p = 0.030$) and pelvis difference maxima (PD_{max}) ($F(3,30) = 0.231$, $P = 0.874$, $\eta^2p = 0.023$).

3.4. Limb Kinematics

Hindlimb protraction was statistically significant under different interventions ($P = 0.000152$) (**Figure 6**). Pairwise comparisons revealed statistically significant differences in hindlimb protraction between conditions ($\chi^2(3) = 20.2$, $P < 0.001$). Tape alone had increased hindlimb protraction (Mdn = 11.06°) compared with tape and poles (Mdn = 9.44°) ($P < 0.001$) and poles only (Mdn = 9.38°) ($P < 0.001$). Furthermore, no intervention (Mdn = 10.2°) had higher hindlimb protraction than poles alone ($P < 0.001$) and tape and poles ($P < 0.001$), showing that poles reduced protraction in general. The results showed no significant effects for the following: forelimb protraction ($\chi^2(3) = 2.45$, $P = 0.484$); forelimb retraction ($F(3,30) = 2.40$, $P = 0.088$, $\eta^2p = 0.193$); and hindlimb retraction ($F(3,30) = 0.724$, $P = 0.546$, $\eta^2p = 0.067$).

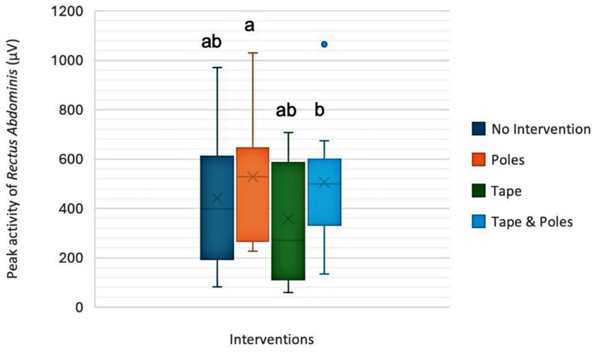

Figure 4: Peak rectus abdominis activity (V) for 11 horses trotting over ground (no intervention), over poles, with kinesiotape only, and over poles with kinesiotape. The boxplot displays the first (bottom) and third (top) quartiles, with the median shown as a band and the mean indicated by an x. Whiskers represent the minimum and maximum values. Significant differences are denoted by * for $P < 0.05$ and ** for $P < 0.01$.

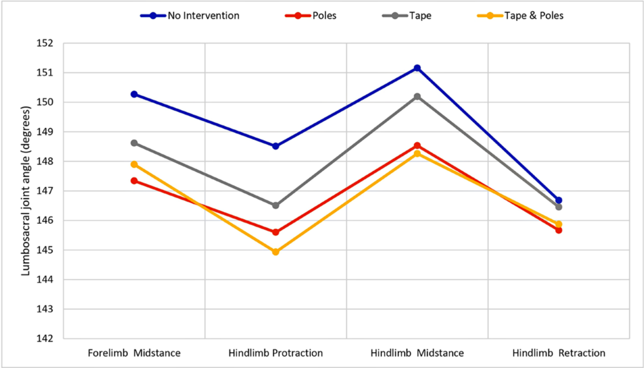

Figure 5: Linear graph displaying mean LS angle (degrees) at four points of the stride (forelimb midstance, hindlimb protraction, hindlimb midstance, and hindlimb retraction) for different interventions. The graph illustrates a significant increase in LS flexion at forelimb midstance for poles ($P = 0.049$) and at hindlimb protraction for poles ($P = 0.032$) and tape and poles ($P = 0.008$) compared with no intervention.

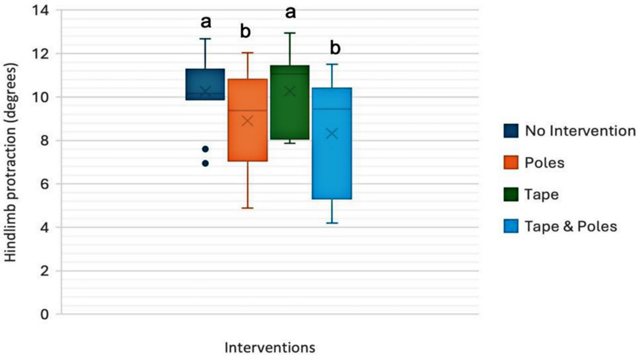

Figure 6: Hindlimb protraction (°) for 11 horses trotting over ground (no intervention), over poles, with kinesiotape only, and over poles with kinesiotape. The boxplot displays the first (bottom) and third (top) quartiles, with the median shown as a band and the mean indicated by an x. Whiskers represent the minimum and maximum values. Significant differences are denoted by different letters.

4. Discussion

The experimental hypotheses can be partially accepted, as significant changes were found in the peak activity of RA, in the LS angle at forelimb midstance and hindlimb protraction, and in hindlimb protraction.

Shaw *et al.* [**12**] reported larger bilateral electrical activity peaks in RA, corresponding to an increased abdominal response to ground poles at both walk and trot. This is in agreement with the findings of the present study, indicating that poles may be beneficial in abdominal engagement [**12**,**14**]. However, current findings reflect brief contractions rather than a sustained increase in average abdominal activity.

Despite researchers suggesting that poles are beneficial for strengthening, there is a lack of evidence on the mechanisms behind muscle activation and poles, with previous research [**22**] reporting no increase in vertical trunk excursion, suggesting that to clear the poles, increased flexion in the limb joints is required. Such a mechanism was observed in earlier pole studies [**22**,**31**,**32**]. Anatomically, achieving a higher flight arch to clear the obstacle requires an increase in concentric contractions of all limb flexors. Moreover, a speed reduction was reported over poles [**22**,**31**,**32**], which could account for the general increase in muscular effort, particularly within the flexor chain.

The antagonist interaction between LD and RA [**1–4**], in accordance with the "bow and string" theory [**33**], keeps the spine stable while opposing increasing forces. Several researchers reported a linear increase in RA activity with speed [**1**,**3**,**34**], which may suggest that with gait progression, RA plays a more important role in maintaining spinal stability than LD [**8**]. While another study [**35**] argued that LD activity appears to be correlated with speed on a straight line, there seems to be variability in response to different training aids. For instance, it has been reported that there was greater LD activity in the control group compared to side reins and Pessoa [**10**], while reduced LD activity was observed with the abdominal band at walk and trot [**12**]. Accordingly, caution is advised when implementing the abdominal band, due to the potential reduction in epaxial activity [**24**].

Unlike in jumping, LD activity is not required to increase suspension over poles. Instead, it continues to stabilize the skeleton during limb flexion over poles [**22**,**36**]. It could be argued that the lack of significant change in epaxial activity in this study could indicate flexor chain activation, observed in peak RA activity, associated with desirable hindlimb engagement [**37**].

Nevertheless, LD was only analyzed for nine out of eleven horses due to the inconsistency of sEMG readings, which may have had an impact on the results. Moreover, the present research included only sound horses, whereas the activation pattern of LD shows significant variability in lame horses [**38**].

The abdominal resistance band, similarly to KT, is thought to stimulate mechanoreceptors embedded in the underlying tissue [**9**,**15**,**18**]. Using an abdominal band, research found a statistically significant increase in the peak activity of the left RA (unilateral findings may reflect a lateral bias, associated with paired muscular groups [**39**]). Due to the richer innervation of equine skin with sensory receptors [**18**], an increase in muscular activity could therefore be expected as a response to tactile stimulation by KT [**20**]. Despite the average RA activity being highest with tape among other conditions, current results do not support this assumption. Moreover, the results are not directly comparable with previous studies on abdominal taping [**15**], which used a different taping approach and did not assess muscular activity, while other studies [**16**], despite applying a similar technique, interpreted kinematic changes as a result of increased abdominal activity without monitoring muscular activity. On the contrary, given that peak RA activity was lowest in the tape condition, KT may have facilitated a more consistent average muscular response in this study.

The LS angle was measured at four points of the stride as per previously published research [**25**]. A marginally significant difference was reported at forelimb midstance for poles, where the LS angle was reduced compared with the no-intervention group. A further significant difference was found at maximal hindlimb protraction, where the LS angle decreased with poles and further with tape and poles when compared with the no-intervention group.

In the present study, both poles alone and tape combined with poles increased LS flexion. This change was observed at the maximal protraction of the stride, corroborating previous findings [**6**], which reported that the maximal LS flexion occurs during hindlimb protraction. The marginally significant increase in LS flexion at forelimb midstance may represent a pre-phase before hindlimb protraction, when the limb is accelerating over the pole, and LS flexion starts to increase. Considering that an increase in abdominal activity was seen in the pole condition, the current findings may support the proposed association of the LS angle with abdominal activity [**16**].

The combination of tape and poles did not appear significantly different from poles only. Although the LS angle did not reach statistical significance for the tape condition, a numerical difference was observed, but this should therefore be interpreted with caution. This may be explained as a minor response from *M. cutaneus trunci* to tactile stimulation and its fascial connections with the underlying RA [**20**], causing a kinematic response. Limited changes may also link to the diagonal nature of the trot, which is likely to limit the LS angulation in comparison to non-symmetrical gaits [**6**].

Data from inertial sensors showed no significant difference in minimum or maximum pelvis differences, showing that none of the interventions negatively affect pelvic symmetry. Inertial sensors are not commonly used in studies examining poles or abdominal tape, except for one study [**31**], which found a significant reduction in craniocaudal movement of the tuber sacrale and coxae and an increase in mediolateral motion when horses moved over poles. However, no evidence of pelvic symmetry was provided, which makes further comparisons challenging.

In accordance with the statistical analysis, the only significant result for limb kinematics was found in hindlimb protraction, which was most prominent with KT, followed by the no-intervention group, when compared with either pole condition.

Maintaining a full range of motion (ROM) is a common goal in rehabilitation, and an increase in protraction, associated with desirable core and hindlimb engagement, is often sought after in equine athletes [21]. Increased hip flexion was reported when trotting over poles [22], and suggested that poles would be beneficial in restoring hindlimb protraction. Despite the expected positive correlation among hindlimb protraction, abdominal activity [1], and LS flexion [22], a reduction in hindlimb protraction may suggest that the chosen pole spacing was limiting hindlimb protraction, although it has not limited LS flexion. This agrees with recently reported findings [40] that protraction/retraction was reduced at shorter pole distances and suggested implementing shorter pole distances in cases where limiting spinal extension is a priority. Previously reported reduction in speed over poles [22,31] may also have contributed to changes in hindlimb kinematics in the present study [41].

Previous KT research [16] observed a decrease in stride frequency, thus, potential lengthening of the stride with KT under its influence. Nevertheless, there was no statistically significant difference in hindlimb protraction between the no-intervention and KT group. Although abdominal taping may not significantly promote limb kinematics in this study, the results suggest that the current KT application was not restrictive to limb kinematics, as opposed to poles in this research.

Our study was not without limitations. Firstly, and most importantly, speed was not objectively measured, and all horses were trotted at their preferred speed as in previous studies [12,15,16]. Although horses were trotted at a consistent, handler-controlled pace, velocity differences between conditions were not quantified and may have influenced muscle activation and kinematic variables. Speed represents a significant potential confounder in this study. Rectus abdominis activity has been shown to increase linearly with trotting velocity [1]. Previous pole studies have reported reduced speed over poles [22,31]. If speed was reduced in the pole conditions, alterations in muscle activity and lumbosacral kinematics may partly reflect velocity-related adaptations rather than a direct mechanical effect of poles. As speed was not objectively measured, its contribution cannot be excluded. Future studies should incorporate velocity tracking to distinguish between speed-dependent and intervention-dependent effects.

Surface EMG is inherently limited by susceptibility to crosstalk from adjacent musculature, particularly in regions with overlapping muscle bellies, which is not the case in the muscles included in this study. However, the recorded signals may still not exclusively represent rectus abdominis or longissimus dorsi activity. Furthermore, unilateral electrode placement does not account for potential asymmetry or lateral dominance. In an ideal scenario, measurements should have been taken from both sides simultaneously to understand the effects of laterality. Given previously reported side-to-side variability in equine trunk muscles [30], bilateral recordings would have strengthened interpretation.

Another limitation was the use of two-dimensional kinematics. Two-dimensional kinematic analysis restricts assessment to sagittal-plane motion and does not capture transverse- or frontal-plane spinal dynamics. The equine lumbosacral region exhibits complex three-dimensional motion, including axial rotation and lateral bending. Therefore, subtle multi-planar adaptations to pole exercise or taping may not have been detected. Three-dimensional motion capture would provide a more comprehensive assessment of spinal biomechanics. Furthermore, potential marker displacement may have limited the reliability of the captured data.

Although the evidence on the lasting KT effect is controversial [16,42,43], it may have impacted the data collected after KT conditions. As opposed to other KT research [15], data for all conditions in our study were collected within one day. Due to the lengthy data collection, the positive effect of warm-up and fatigue on locomotor parameters must also be considered [44]. Even with a small adjustment allowance, fixed pole spacing may not account for individual horse stride length, thus reducing protraction/retraction [40], as well as reducing applicability to ridden trot [31].

Lastly, surface electromyography (sEMG) also presents several inherent limitations that should be acknowledged when interpreting these findings. sEMG signals can be influenced by factors unrelated to neuromuscular activation, including subcutaneous adipose tissue thickness, skin impedance, and electrode placement variability. Although efforts were made to standardize the study population, individual differences in fitness level, muscle fiber composition, and body condition score (BCS) were not objectively quantified and may have affected signal amplitude and muscle recruitment patterns. These factors are well recognized in both equine and human sEMG research and can contribute to inter-individual variability, potentially masking subtle intervention effects. Consequently, the recorded activity should be interpreted as an indirect estimate of muscle function rather than a definitive measure of muscle force or activation.

5. Conclusion

Ground poles were associated with increased peak rectus abdominis activity and reduced lumbosacral angle at specific stride phases. These findings suggest a potential role for pole exercise in influencing trunk muscle activation and lumbosacral kinematics, although effects were phase-specific and modest in magnitude. This could create recommendations that poles should be used in conditioning and rehabilitation programs for core strengthening and lumbosacral motion maintenance. However, pole spacing must be carefully considered regarding the purpose of rehabilitation, as LS extension and hindlimb protraction are affected. Kinesiotaping did not independently alter muscle activity or most kinematic variables. Any potential additive effect when combined with poles remains speculative and requires confirmation in larger, controlled studies. Therefore, there is a need for more research on this method and its longitudinal effects to understand the mechanism and tailor rehabilitation to individual horses in the most efficient way.

Authors' Contributions

A.S.: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft; H.J.: Methodology, Project administration, Supervision, Writing – review & editing; R.B.: Conceptualization, Methodology, Resources, Software, Writing – original draft, Writing – review & editing.

Data Availability

The data that support the findings of this study are available from a public repository at: https://data.mendeley.com/datasets/yv2yyb9xc8/1.

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Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose. This research has been presented as a conference abstract at the Alltech-Hartpury Student Conference 2023 (A.S.; H.J.) and IAVRPT Conference 2024 (A.S.; H.J.; R.B.).

Ethical Approval

The current study was approved by the Ethical Committee at Writtle University College (number: 98379136/2023). The study was carried out in accordance with guidance on the operation of the Animals (Scientific Procedures) Act 1986 and associated guidelines. The welfare of all animals was monitored according to a strict protocol, and any distress or decline in condition would result in exclusion from the experiment and appropriate veterinary attention. Fresh water for horses was provided throughout the data collection.

Consent to Participate

Written informed consent was obtained from all owners of horses participating in the study.

Declaration of Generative AI and AI-Assisted Technologies

The authors confirm that no Generative AI or AI-assisted technologies were used in the writing, editing, or preparation of this manuscript. The entire content was authored solely by the individuals listed.

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