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Effect of a 4-week elastic resistance band training regimen on back kinematics in horses trotting in-hand and on the lunge.

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Objectives: To quantify the effects of a specific resistance band system on back kinematics during trot in-hand and during lungeing at beginning and end of a 4-week exercise programme.

Study design: Quantitative analysis of back movement before/after a 4-week exercise programme.

Methods: Inertial sensor data were collected from seven horses at week 1 and 4 of an exercise protocol with elastic resistance bands. Translational (dorsoventral, mediolateral) and rotational (roll, pitch) range of motion of six landmarks from poll to coccygeal region were quantified during trot in-hand (hard surface) and during lungeing (soft surface, both reins) with/without elastic exercise bands. A mixed model ($p<0.05$) evaluated the effects of exercise bands, time (week) and movement direction (straight, left, right).

Results: The bands reduced roll, pitch and mediolateral displacement in the thoracolumbar rotational (

Equipment

Each horse was fitted with its own bridle and a modified saddlepad[a] to which the elastic hindquarter and abdominal bands were attached using buckle clips. The bands were fitted at 30% tension (see Fig 1). Each handler was requested to check on a weekly basis that the tension was maintained at 30%. Band tension was checked by the person collecting the data at week 1 and 4 prior to data collection.

ht MTx[b] IMUs were attached to the horse with custom ma CID 3 BDC 88.656 583.96 T1 e horoteen-5.2T

displacements were calculated based on highpass filtering with frequencies of 1.5 Hz for integration from dorsoventral acceleration to displacement and of 0.75 Hz for integration from mediolateral acceleration to displacement [14]. After stride segmentation [24], four range of motion parameters were calculated per sensor and stride (translational: dorsoventral V) and mediolateral (ML) displacement; rotational: roll (R) and pitch (P)) as the difference between maximum and minimum value over a stride cycle. These parameters were calculated for the six sensors mounted along the midline of the horse from the poll to the base of the tail for the initial assessment without and with bands (week 1, day 3) and for the final assessment without and with bands (week4, day 7).

Movement symmetry measures: Movement symmetry was calculated for the initial assessment without bands (week 1, day 3) as an indicator of force distribution between contralateral limbs [25 27]. The symmetry parameters are based on vertical displacement of poll and pelvis (*os sacrum* sensor) and specifically were MinD, the difference between displacement minima during right fore (pelvis: left hind) and left fore (pelvis: right hind) stance and MaxD, the difference between displacement maxima after right fore (pelvis: left hind) and left fore (pelvis: right hind) stance [28]. The difference between left and right tuber coxae upward movement (hip hike difference, HHD) was calculated [29]. All symmetry parameters were expressed in mm (zero indicating perfect symmetry). For head (pelvic) movement, positive MinD indicates a higher position of the head during RF stance (of the pelvis during LH stance) and a positive MaxD indicates a higher position of the head after RF stance (of the pelvis after LH stance).

Stride time: As part of the stride segmentation procedure, stride time (in ms) was extracted for each identified stride. Average stride time values for each horse for each exercise condition were calculated.

Data Analysis: A mixed linear model was implemented in SPSS[d], with level of significance of $P<0.05$ and translational and rotational range of motion as dependent parameters, horse as a random factor and band condition (with or without), direction (straight, left rein, right rein) and time (week1, week4) as fixed factors and stride time as a covariate. The three main effects as well as all three possible two-way interactions and the three-way interaction between band condition, direction and time were assessed. Within each horse, stride time varied from its subject mean by on average ±5% (±3.8% to ±7% across horses). As a result, stride time was entered linearly into the model.

Model residual histograms were inspected visually for outliers. Estimated marginal means of factors with $P<0.05$ were inspected, and post-hoc tests were carried out (Bonferroni), to establish pairwise significant differences for factors with more than two categories (i.e. direction with p-value of 0.05/3).

Results

In total, range of motion data were calculated from 3215 strides of 7 horses assessed at two time points (week1, week4), for two band conditions (without, with) and three movement direction (straight, left rein, right rein). Mean values for each horse for each of the 12 conditions were calculated from an average of 38.3 strides (between 25 and 89 strides per condition). These mean values were used for statistical analysis.

Stride time was on average across all conditions 739 ms (median: 737.5 ms, range: 660 ms to 818 ms). On the straight, average stride time was 724 ms (median: 728.5 ms) compared to 749 ms (744.5 ms) on the left rein and 745 ms (739.5 ms) on the right rein. Average stride time for assessment without exercise bands was 740 ms (738.5 ms) and with the bands 738 ms (737.5 ms). At week 1, stride time was found to be 732 ms (732 ms) and 746 ms (752 ms) at week 4.

Movement Symmetry

Movement symmetry parameters for head (MinD, MaxD) and pelvis (MinD, MaxD, HHD) for the horses during the initial data collection session before application of the exercise bands are summarised in Figure 2. With the exception of pelvic MinD, interquartile ranges (boxes) for the symmetry values recorded during in-hand (straight line) trot include zero (perfect symmetry) with considerable spread seen across the seven horses.

Direction: 79% (19/24) of back kinematic parameters showed a significant effect for direction (Table 1 and Supplementary Item 2). The majority showed significant differences between straight line and left rein and ben straight-4Tm[oscght line and right rein. Two of the paramen strers (med[oscolateral-4T poll range of motion and coccygeal pitch) additionally showed differences ben straileft and right rein while three paramen strers only showed differences between straight line and one of the reins (dorsoventral withet-4Ts and pelvis range of motion and lumbar roll range of motion). All values were greater on the lunge compared to straight line movement. Average change between straight line and lungeing (average of left and right rein) of 10% increase was measured for dorsoventral movement (for 6 sensors), 24% increase for med[oscolateral movement (for 6 sensors), 16% increase for roll (for 4 sensors) and 23% increase for pitch (for 3 sensors).

Discussion

We quantified the effects of a spec[oscfic system of elastic resistance on back kinematic paramen strers in seven riding horses over a 4-week period. The resistance bands significantly-4T reduced

In comparison to the Pessoa training aid (PTA) [6], the resistance bands did not have a direct effect on lumbosacral flexion (pitch) or overall dorsoventral displacement. Dorsoventral displacement was increased at week 4 however independent of band usage. Whether or not this indicates an effect of the band usage over 4 weeks allowing the horses to push off into the air more efficiently needs to be addressed by future studies. We used a range of horses of different breed and age. Published *in vitro* work found that around one third of horses have anatomical variations in the lumbosacral area which may impact on maximal dorsoventral displacement [32], however, presence of anatomical variations was not assessed here. In comparison to attachments of the PTA, t does not have a direct con mouth and hence avoids the oral desensitisation effects seen with orrect use of the PTA [33] when using the EquiBand™ system during lungeing. The system can of course also be used during ridden exercise.

We assessed horses in-hand and on the lunge. A high proportion of parameters across all regions showed increased ranges of motion on the lunge compared to straight line trot. Previous studies on lungeing have mainly focused on movement symmetry and limb angles of horses on the lunge [34 38], providing little scope for comparison. However, the increased ranges of motion are likely, independent of band usage, related to the additional production of centripetal force of locomotion on a curve, resulting in an increase in total force [39] and increased peak forces measured in the outside front limb [40]. As demonstrated with the PTA [6] on the lunge, the greater dorsoventral displacement and lumbosacral flexion (pitch) may be related to increased activation of core postural muscles.

Only 5 differences in movement parameters were measured between weeterhot1hand and on1c-.3 0 1uo70.515

in walk after removal of the bands. The existence of a carry-over effect should be investigated further in future studies with a series of repeat assessments after removal of the bands.

Conclusion and future work

This study provides quantitative evidence to suggest that use of a specific elastic exercise as part of an exercise protocol, increases dynamic stability of the thoracolumbar area in the trotting horse in-hand and on the lunge. The study design did not allow a judgement of whether the exercise regimen alone (without the band system) would have similar effects. Further studies should identify whether the

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Table

Table 1: 5í 6G VY [îîÎÔ¢í5ÄâÖvêÒíí Ô¢í5Äájí½ÎëÜ P z³/jí5ÄnÞÖq f•c„ 5þØ~îÔæ¢fq 3

Figure legends

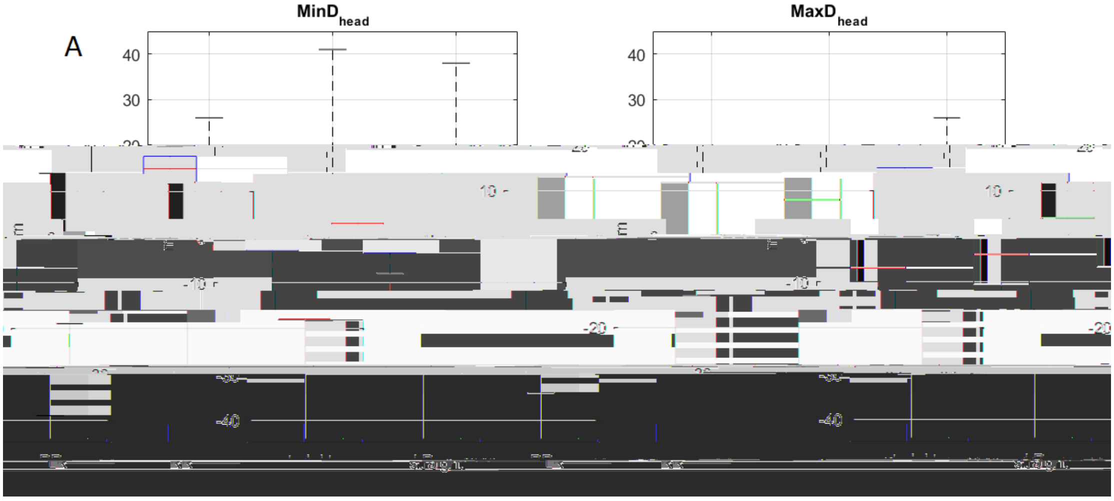
Fig 1:

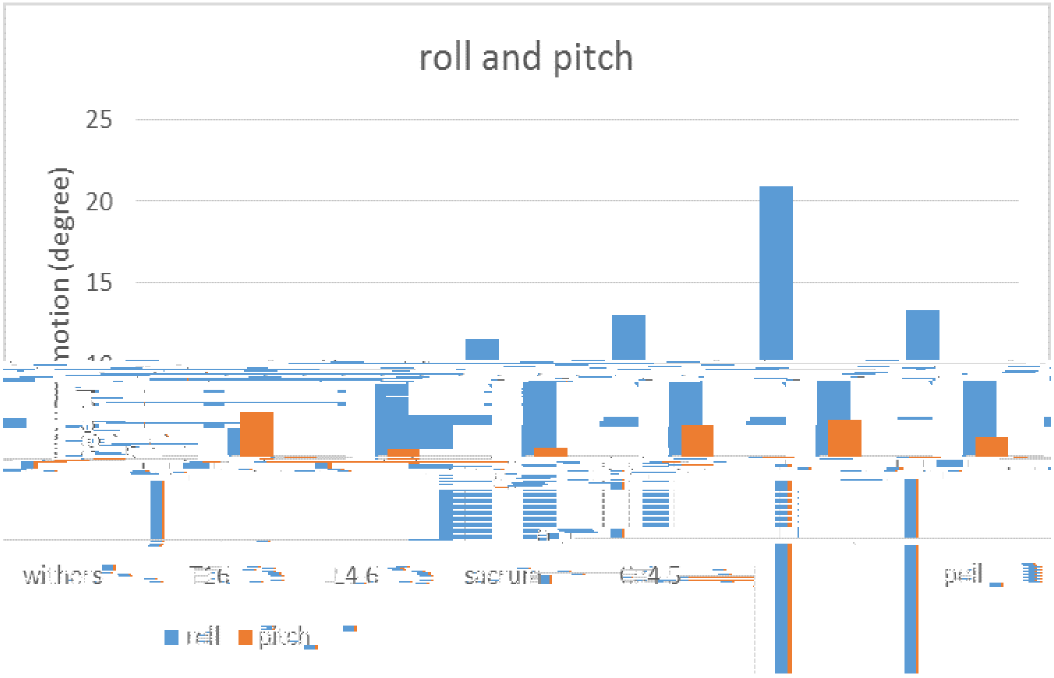
straight-line trot and while trotting on the lunge (N = 42 values per box). All four significant changes result in a reduced range of motion (increased dynamic stability) with the use of the bands.

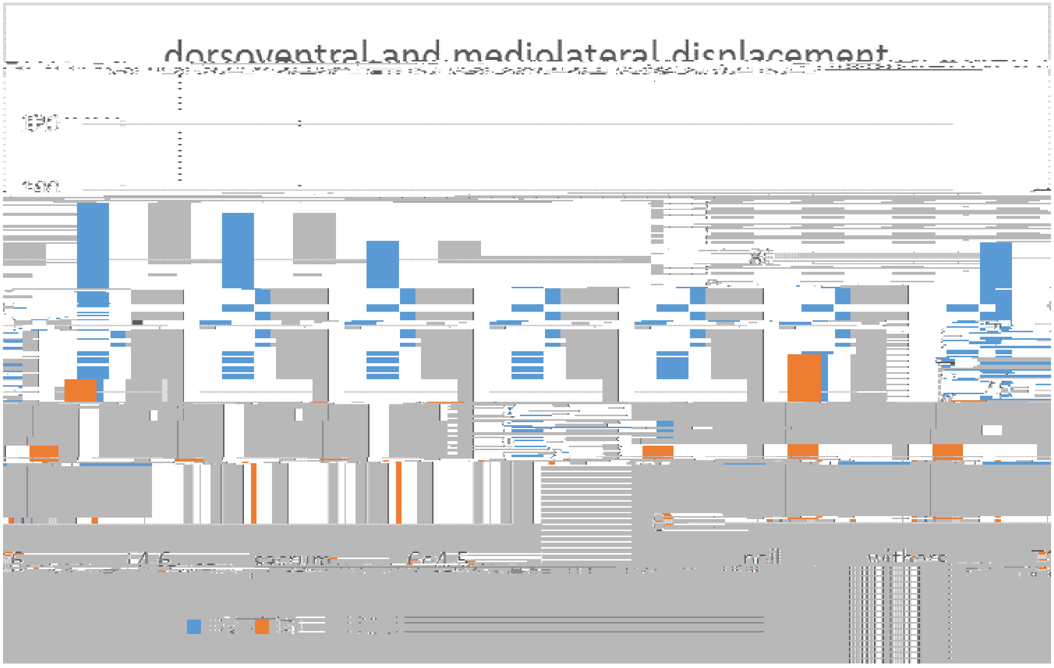
Supplementary Information

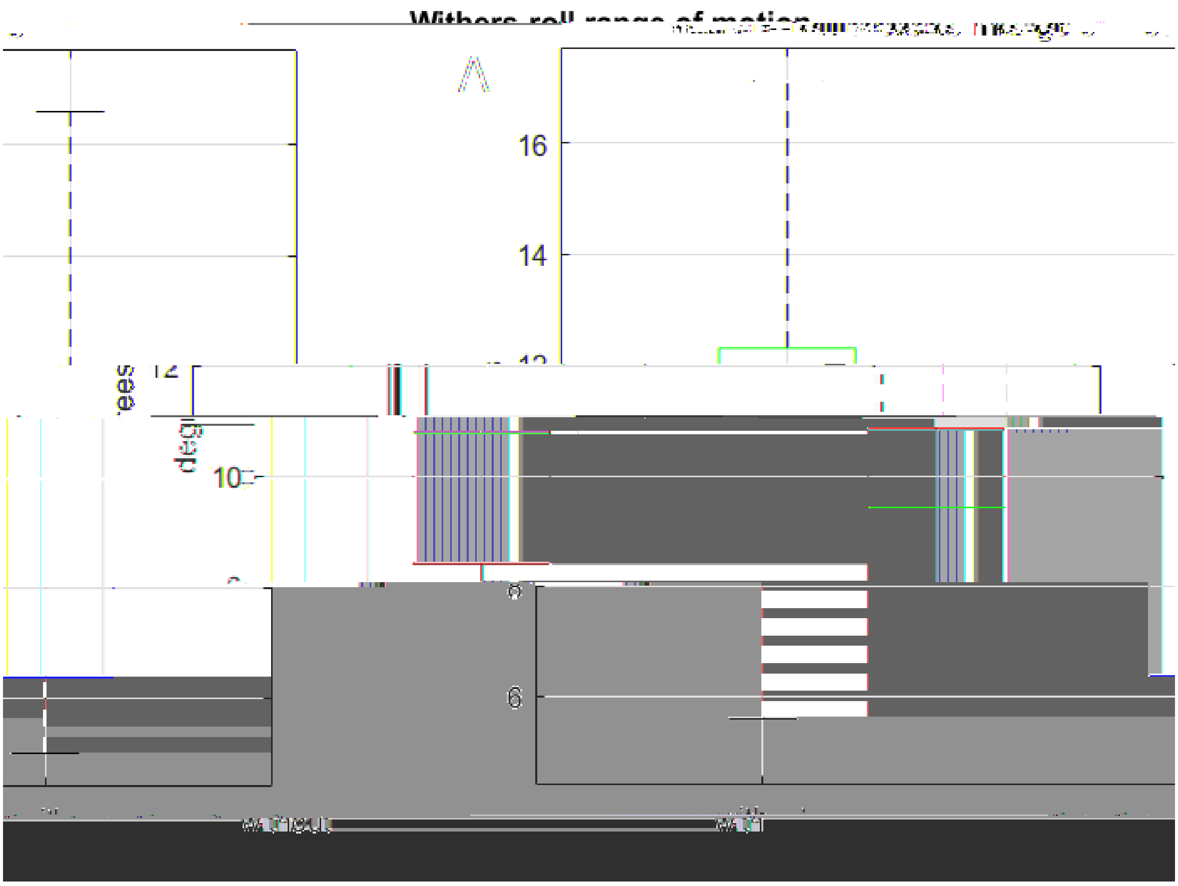
Supplementary Item 1: Horse details.

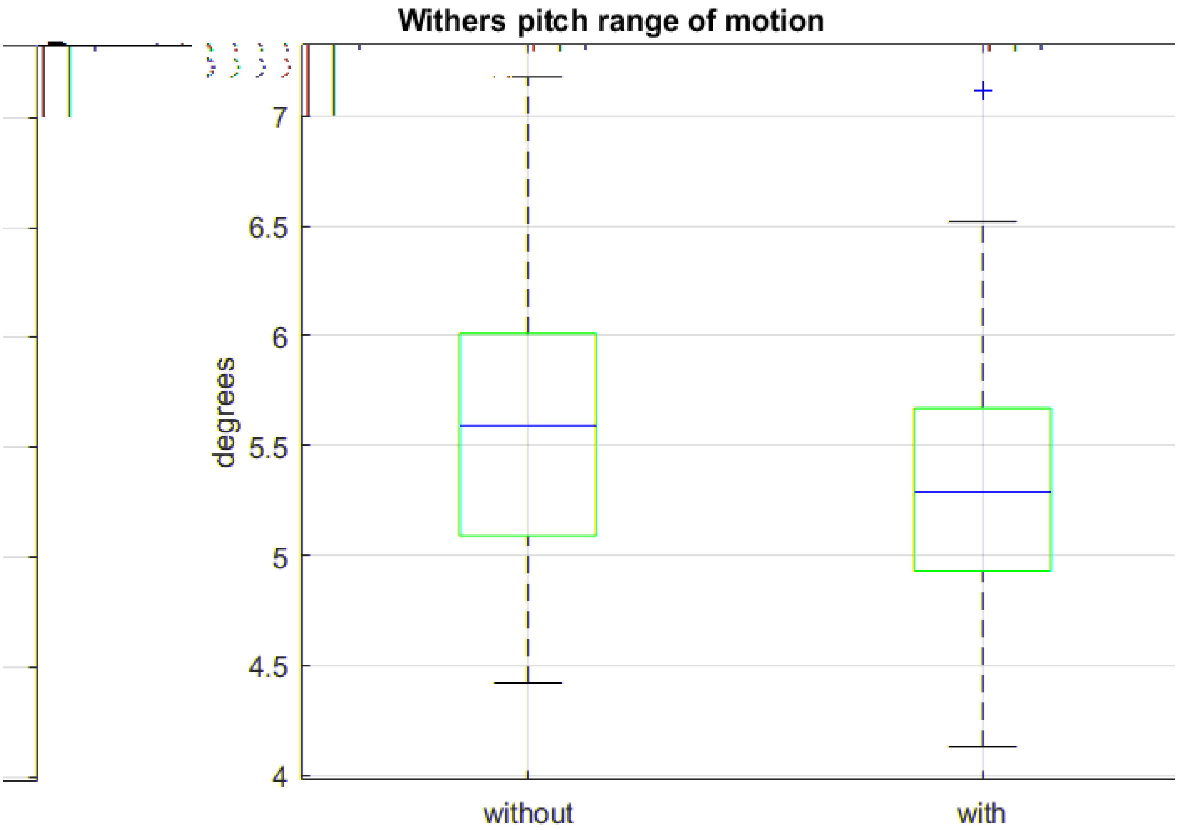
Supplementary Item 2: Mixed model analysis for range of motion parameters.

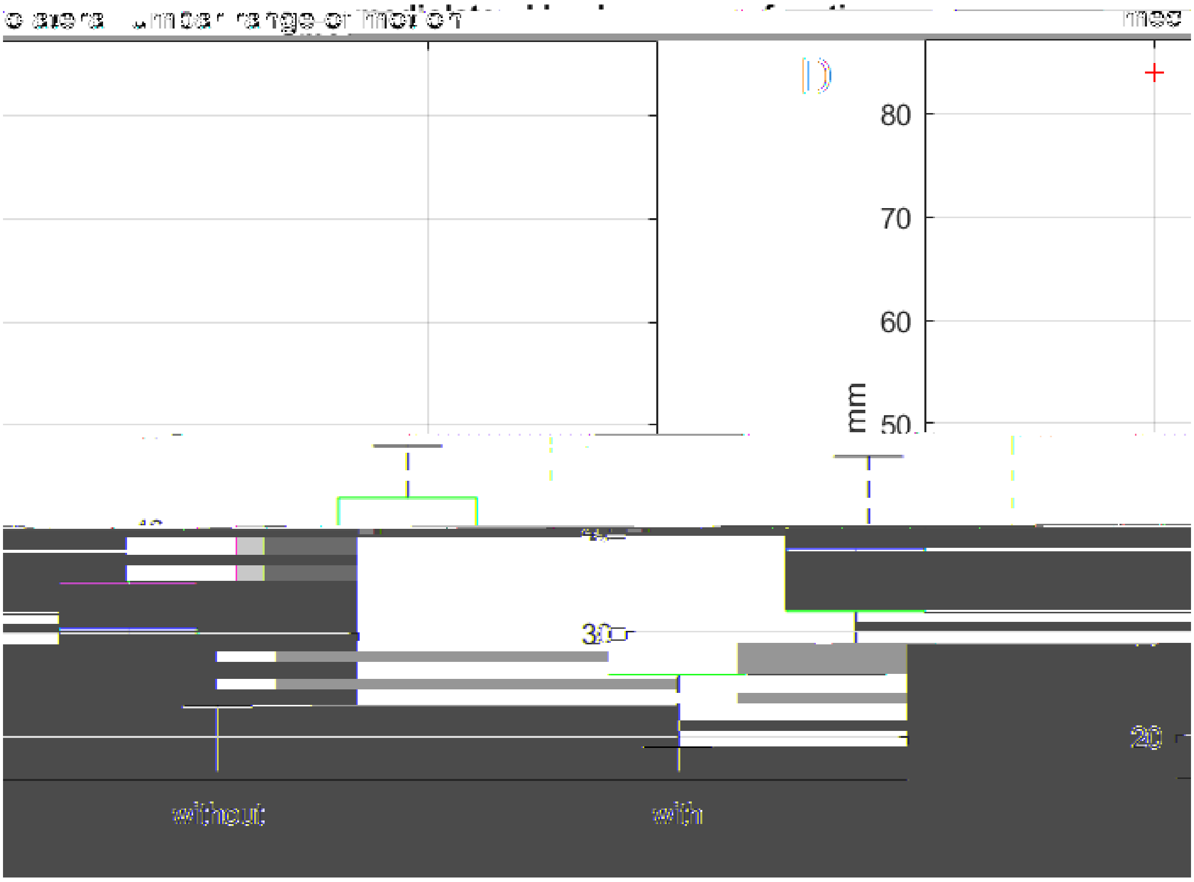

A
MinD$_{head}$
MaxD$_{head}$
40
30


roll and pitch
25
20
15
roll
pitch


dorsoventral and mediolateral displacement


Withers roll range of motion
16
14
10
6


Withers pitch range of motion
degrees
7
6.5
6
5.5
5
4.5
4
without
with


80
70
60
50
mm
without
with