A Comparison of the Forces Acting on the Horse's Back under a Half-Tree and Full-Tree Race Exercise Saddle at Walk and Trot

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Introduction

Horse racing is one of the largest industries in Britain with an average of 15,345 horses in training (British Horse Racing, 2009). Back problems are common among thoroughbred racehorses and can lead to poor performance, lameness and major wastage of racehorse (Gomez Alvarez *et al.* 2007: Haussler 1996; Jeffcott *et al.* 1982; Williams *et al.* 2001). Knowledge of the effects of rider and saddle on the equine back is crucial for the understanding of the aetiology and pathogenesis of back problems in the horse (Peham *et al.* 2004). Saddle fit is an important factor in the pathogenesis of back problems (De Cocq *et al.*, 2006; Harman, 1995a). Saddle fit has been shown to affect the forces acting on the horse's back (Meschan *et al.* 2007) and is seen as one of the biggest causes of back pain (De Cocq *et al.* 2004 Jeffcott *et al.*, 1999; Harman 1995a), frequently playing a major role in poor performance syndrome, due to poor fit or improper positioning (Harman 1995a, 1997; Jeffcott *et al.*, 1999: Turner *et al.* 2004). A non-fitting saddle has been shown to cause an increase of variability in the horse's motion pattern (Peham *et al.* 2004) misbalancing the rider's seat (Haussler, 1999) resulting in distribution of pressure over a smaller area than under a proper fitting saddle (Meschan *et al.* 2007), potentially causing injury. Race exercise saddles are used with a 'fit anything' approach (Bromiley, 2006) and half-tree saddles in particular put pressure on the horse's back and spinous processes (Bromiley, 2006; Harman, 1999) leading to the belief that they must be linked to poor performance. Therefore, pressure and the effects of pressure caused by race exercise saddles require investigation. Pressure under saddle can be reliably investigated using an electronic saddle pad (Jeffcott *et al.* 1999; De Cocq *et al.* 2006; Peham *et al.* 2010) under standardised conditions (Jeffcott *et al.* 1999). Computerised saddle pressure measuring devices allow study of poor saddle fit, different pads, and different saddle-rider combinations (Harman 1999). Overall force measurement at a walk and trot has been shown to be objective criterion for saddle fit (Meschan *et al.* 2007). Tekscan sensing technology has been proven to be accurate and reliable in the medical sector (Ahroni *et al.* 1998; De Marco *et al.* 2000; Williams, 2000), but evaluation of the accuracy and reliability of the system for dynamic assessment of pressure under saddle has yet to be carried out. The aim of this study to compare force under the half-tree and full-tree race exercise saddles, at walk and trot, ridden in a riding style that is normally used under racehorse training conditions, using the *Tekscan CONFORmat* pressure sensing system. The sensor mat uses wireless technology and it is contained within a purposely designed saddle pad (*Saddle Research Trust*), to fit the sensor mat and all the hardware components, which can be easily positioned on the horse's back.

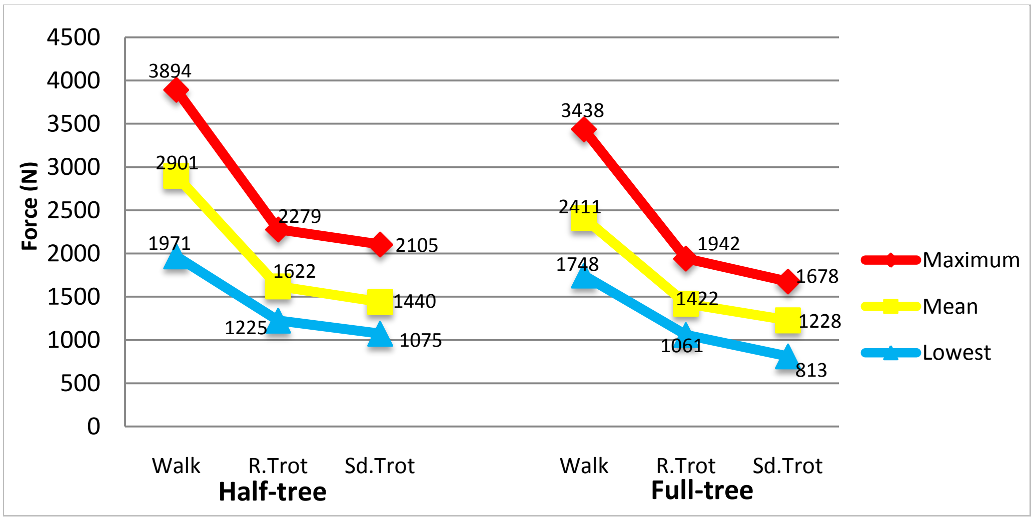
Methodology

Nine horses were ridden by the same experienced rider in a half-tree race exercise saddle and a full-tree race exercise saddle using a standardised protocol in an indoor school. The *Tekscan* pressure sensing mat was place on the horse by a professional and the horse was tacked up by the rider as per normal conditions in a racehorse training yard. The pressure mat remained on the horse's back between saddle changes in order to improve repeatability and prevent inconsistencies in placement and pressure distribution as per previously described methods (De Cocq *et al.* 2009; Kotschwar *et al.* 2009). Pressure readings of 50 frames per 1 second intervals were taken in real-time producing around 800 sets of measurements (frames) for each horse in each section and data was synchronised with digital video. Based on the methods of De Cocq *et al.* (2010), sections and strides were correlated with kinematic events using video recordings and individual stride cycles were extracted. At least ten strides were recorded for each horse in both saddles in three sections: walk (W), rising trot (R.T), trot with the rider in standing/jockey position (Sd.T). Pressure values were converted to force values (Newtons) for statistical analysis using previously described equations (Winkelmayr *et al.* 2006). Mean force for each horse in each saddle, in each section was calculated. Data from six horses was used to analyse total force and force of under quarters of the saddle. A Kolmogorov-Smirnov test confirmed data was normally distributed and ANOVA and paired-T tests were used to evaluate significant differences between the force of saddle groups, sections and individuals.

Results

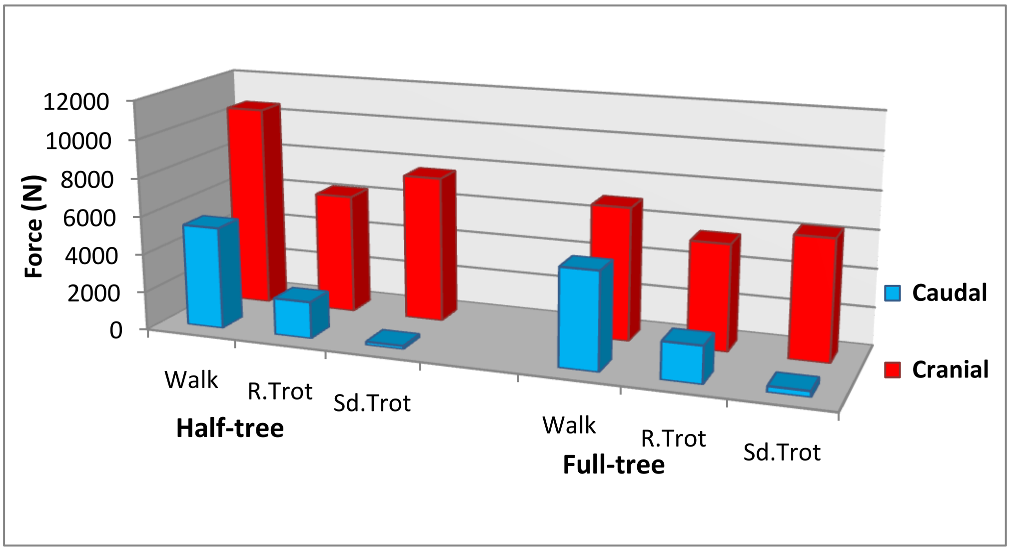
There was no significant difference between overall mean force of the half-tree and full-tree saddle (P= 0.124). Force measurement was higher in the half-tree saddle. Total mean force was significantly different between all gait sections. For the majority of horses overall mean force was higher in the half-tree saddle. Force in each section; walk, rising trot and standing trot were significantly different to each other and had a characteristic force pattern as found in other studies (Fruehwirth *et al.* 2004; Jeffcott *et al.* 1999; Pullin *et al.* 1996; von Peinen *et al.* 2009). Mean force in the Half-tree saddle was 2900.97 N ± 683.7 at Walk, 1621.51 N ± 402.25 at Rising Trot and 1439.53 N ± 357.54 at Standing Trot. Mean force in the Full-tree saddle was 2411.40 N ± 771.75 at Walk, 1621.51 N ± 419.08 at Rising Trot and 1228.27 N ± 372.87 at Standing Trot. The maximum force reached was 3893.73 N in the Half-tree saddle at Walk, and the lowest force reached was 812.73 N in the Full-tree saddle at Standing Trot. Maximum, mean and lowest values in each section are shown in figure 1. Each horse followed a pattern for both saddles where force was highest in the walk then decreased significantly in rising trot (42-45%) followed by a smaller but still significant decrease in standing trot (12-14%). High variation occurred between individuals ($P=7.46 \times 10^{-8}$).

Figure 1. Maximum, Mean and Lowest Overall Force values of the population in each gait.



The saddle tree did not have a significant effect on the quarter forces but quarters were significantly different from each other ($P=9.16 \times 10^{-6}$). The variation between the mean overall quarter force of individual horses in both groups was also highly significant ($P=9.16 \times 10^{-6}$). Force was highest in the cranial half of saddle for all thee gaits in both saddles. Quarter forces were not significantly different between the rising and standing trot ($P>0.05$). The trend of Cranial and Caudal forces within each section is shown in figure 2.

Figure 2: Trend of Cranial and Caudal Forces (N) in Half-tree and Full-tree saddles in each section



Discussion

Standardised methodology, the same rider, consistent placement of the mat and daily calibration, is required to produce reliable and accurate pressure measurements under saddle (De Cocq *et al.* 2006). These recommendations were adhered to in the present study, however, the technology used was in a prototype stage and malfunction in recording rate did occur which questions the reliability of the system. The malfunctions reduced the numbers in an already small population; nonetheless, a pattern was evident. Sensor sensitivity has been shown to vary over time depending on the system used (De Cocq *et al.* 2009) therefore without analysis of variation being carried out for the system in this study, results cannot be interpreted with absolute certainty. However, a clear trend was shown between sections and saddles, force was higher for the half-tree saddle, force is highly variable between horses under both saddles, and, force decreased when the rider was in a standing/jockey position.

The half-tree saddles produced greater force measurements than the full-tree saddle, but this was not significant. High variation from the mean within the full-tree group indicated that individual horses respond differently to full-tree saddles. Individual horse's mean force value varied very significantly from one another for both saddle types indicating the varied response saddle fit, and confirming that one saddle does not fit all. In addition quarter force for individuals was very significantly different between saddle groups and within groups. Force was generally higher and varied considerably more for individuals and sections under the half-tree saddle showing the amount of force caused by the half-tree saddle is perhaps less predictable for individual horses. The high individual variation is mostly likely due to differences in conformation. Some individuals mean force in the half-tree differed significantly to their mean force in the full-tree. Although this did not affect the overall result that force was not significantly different between saddles, it indicates horses had a significantly different response to the different saddles, supporting the fact that variation between horses, means saddle fit needs to be considered on an individual basis. Considerable variations can occur in pressure patterns in healthy horses and even in the same horse under different circumstances (Holmes and Jeffcott, 2006). Variation of the width of the spinous process can occur between different breeds and individuals of the same breed (Ridgeway 2006) affecting pressure patterns beneath the saddle. Breathing, muscle tension and changes in the body posture of the horse will also influence the pressure pattern under the saddle (Winkelmayr *et al.* 2006). In the current study, using each horse as its own control allows for comparison of both saddles on each individual, therefore reducing the confounding affects of body shape muscle tension.

Force at walk, rising trot and standing trot were significantly different to each other and each had a characteristic force pattern as found in other studies (Fruehwirth *et al.* 2004; Jeffcott *et al.* 1999; Pullin *et al.* 1996; von Peinen *et al.* 2009). The trot characteristically has a very stable back with reduced range of movement and with major restraining influences of the muscles that affect the back (Johnston *et al.* 2002). Therefore forces are reduced at trot. Standing trot forces were significantly lower than walk or rising trot sections. Forces in the cranial section decreased from walk to rising trot and increased at standing trot. Overall force, quadrant force and maximum value for overall force were significantly lower in the standing position as the legs act as an elastic coupling reducing peak force under saddle (De Cocq *et al.* 2010). This is in agreement with Peham *et al.* (2010) finding force in the two-point seat produced significantly lower force than rising or sitting trot. In the two-point seat the rider absorbs the maximum overall force by pushing his knees against the saddle during the motion cycle (Peham *et al.* 2010). In the present study, standing trot allows the rider to absorb force in the same way therefore, values for forces are lower in standing trot indicating that this position is less demanding for the horse. However, considering most horses are walked and trotted for approximately half of the time they exercise each day (Rogers *et al.* 2006) the greater forces in the half-tree saddle, although not significant, would suggest, in the absence of a fitted saddle, the full-tree saddle is a preferable choice for exercise racehorses.

Although force was significantly reduced in the race exercise standing position, at a canter, force may be affected very differently due to the horse's body movements. It could be assumed that kinematics of the thoracolumbar spine may differ again at the gallop, in which case, thorough evaluation of saddle fit should also include this gait.

The results presented here indicate that using the half-tree saddle is likely to cause more overall force in comparison to the full-tree saddle, but, as only two saddle types were tested and high variation between individuals occurred, further investigation is required to confirm this finding. Based on using lowest overall force to define saddle fit (Meschen *et al.* 2007), the full-tree saddle is preferable, but a more detailed interpretation of the affects of force under the saddle at different gaits, including canter and gallop, for a variety of horses and riders, over longer time periods, is required to develop a standard for reasonable fit before either saddle can be conclusively recommended. Considered on an individual basis, lowest force values were similar for individuals in both saddles, unlike the maximum force values. Perhaps these lowest values can then be taken as a representative of the minimum values under race exercise saddles which could then be used as a guideline for future analysis of force.

Rider position and saddle type affect the force distribution underneath the race exercise saddle. The affect of these forces on the horse's back remains to be investigated. Further research is required to determine precise patterns of pressure distribution and the location of potentially harmful pressure concentrations under both saddles which may allow for more confident recommendation of either saddle for use. In conclusion, saddle tree has a significant influence on force and should be considered when training racehorses. Further studies are needed to establish more well-defined conditions for saddle fit in the race horse, and show if the effects of saddle pressure of the kind and magnitude observed under race exercise saddles are significant in terms of horse health and performance.

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