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Original Article

Saddle fitting, recognising an ill-fitting saddle and the consequences of an ill-fitting saddle to horse and rider

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Summary

A saddle that does not fit either a horse or a rider correctly has potentially far reaching consequences for both horse and rider health. The saddle should be assessed off and on the horse, without and with a rider. The fit of the saddle for both the horse and rider must be evaluated. A well-fitted saddle should distribute weight evenly via the panels to the horse's thoracic region, with complete clearance of the spinous processes by the gullet. The saddle should remain fairly still during ridden exercise at all paces. The saddle must also fit the rider to enable them to sit in balance. Signs of an ill-fitting saddle include equine thoracolumbar pain, focal swellings under the saddle, ruffling of the hair, dry spots under the saddle immediately after exercise surrounded by sweat, and abnormal hair wear. If a saddle does not fit the rider, the rider may not be able to ride in balance with the horse, and this may induce equine thoracolumbar pain. A saddle of inappropriate size and shape for the rider may induce rider back pain, 'hip' pain, sores under the 'seat bones' and perineal injuries.

Introduction

A saddle that does not fit either a horse or a rider correctly has potentially far reaching consequences for both horse and rider health. It is therefore important that veterinarians have some knowledge of saddle fit and know how to recognise an ill-fitting saddle. To understand the principle of saddle fitting, it is necessary to have a basic knowledge of terminology (Glossary and **Fig 1**). This article focuses on English saddles and does not cover Western saddles, treeless saddles and other saddles designed for specific activities, e.g. endurance saddles or side saddles.

Sophisticated equipment is generally not required to assess saddle fit. Graphic pictures can be acquired using force mats and thermography, but it must be borne in mind that force distribution is integrally related not only to the fit of the saddle, but also the shape of the horse and the position of the rider. Thermography assesses heat, which does not necessarily have any relationship with force and can be an unreliable tool for accurate assessment of saddle fit (Society of Master Saddlers 2013). Asymmetrical force distribution is just as likely to arise from a crooked rider or lame horse as it is from an ill-fitting saddle. If horse shape and soundness and rider position are assessed in conjunction, then force mat data can provide additional potentially useful information, but much can be learnt from a careful systematic appraisal of the saddle off the horse, the horse's back, the saddle on the horse and the saddle with a rider, not only standing still but also with the horse working.

Scientific reviews of the interactions between the horse, saddle and rider are provided elsewhere (Greve and Dyson 2013a; Dyson and Greve 2015). This review aims to provide practical information about saddle-fit to the horse and rider and the consequences of inappropriate fit.

How to assess saddle fit to a horse

The interface between the saddle and the horse

A well-fitting saddle should have soft flocking, evenly distributed, with a flat, even bearing surface of the panels. The edges of the gullet should be smoothly rounded; the panels should support and cover the tree. The gullet width should be uniform from cranial to caudal and have a minimum width of at least 5 cm.

In general terms, when the saddle is placed on the horse's back, the lowest point of the horse's back should be aligned with the lowest part of the saddle. However, the site of the lowest part of the back varies among horses, depending on factors such as conformation and condition. The lowest part of the seat should be horizontal, and the saddle should not tip forward or backward (**Fig 2**); this also needs to be assessed when ridden because the balance of the saddle may alter according to the gait. There should be uniform contact of the horizontal panels with the horse's back, which should be evaluated by feeling under the saddle with a flat hand for any gaps or tight spots. There should not be any areas where there is either reduced contact or no contact between the panels and the horse's back (**Supplementary Item 1**). The most accurate method is to use coloured builder's chalk powder. Thoroughly and uniformly dust the chalk powder into the horse's coat over the saddle bearing area with a soft paintbrush. Carefully position a clean white cloth under the saddle and ride for approximately 20 min using the usual programme of exercises. Then assess the distribution of the chalk powder on the white cloth. Saddle contact can also be checked by looking at the grease on the saddle, if using the saddle without a numnah. Alternatively, dust the bottom of the saddle with talcum powder and see how it is distributed on the horse's back. Another method is to soak the horse's back thoroughly with water and then assess the distribution of water over the bottom of the saddle. Tight spots are usually found either side of the base of the withers, especially with close contact saddles. Also look at the distribution of sweat on the numnah under the saddle, or look for the presence of

Fig 1: Parts of the saddle: 1, Saddle flap; 2, sweat flap; 3, tree point; 4, girth guard; 5, billet or girth strap; 6, knee roll.

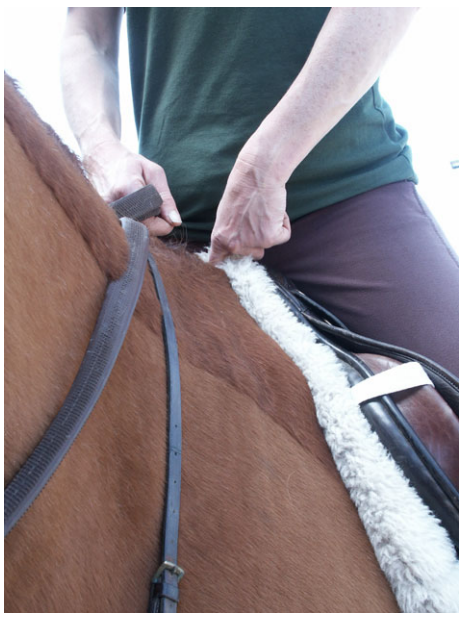

Fig 3: The gullet is too low, with inadequate clearance of the spinous processes. The rider, standing in the stirrups, can only insert a single finger, which is being compressed.

dry spots on the back after exercise, which may indicate pressure points (**Supplementary Item 2**). With conventionally flocked saddles the fit of the panels is best assessed initially without a rider, but with an air-filled saddle this must be done with the girth tightened and a rider on the saddle; air is only distributed evenly when under pressure. The saddle should also be checked with the numnah ± pad (saddle cloth) that the owner is going to use, because this makes a significant difference to the fit (see below and also Pads and numnahs: what is their purpose?).

Check that at least two fingers' width aligned vertically can be inserted under the pommel when the rider is standing in the stirrups, both before and after exercise, i.e. there is clearance of at least 4 cm (**Fig 3**). The gullet should not be in contact with the spine or the sides of the withers when a rider is on the saddle. Check that you can see through the gullet of the saddle from the front and back, bearing in mind that with a deep seated dressage saddle because of the curvature of the seat, it may not be possible to look all the way through. The width of the gullet and the width of the panels must be appropriate to the width and shape of the horse's back, so that the panels do not extend beyond the width of the *longissimus dorsi* muscles and so that there is complete clearance of the spinous processes.

The width and length of the saddle

The width and length of the saddle must be suitable for the shape of the horse's back. The tree points should be three fingers' width (i.e. approximately 6 cm) behind the caudal aspect of the scapular cartilages. When the forelimbs are protracted the scapulae rotate backwards and should have freedom of movement. This can be assessed with the horse standing still, by palpation while each forelimb is pulled forward. The tree points should remain caudal to the caudal aspect of the scapular cartilages. The flexible front panels may overly the scapulae provided that the tree points are caudal to the scapulae. It is also necessary to check that the saddle stays behind the scapulae during exercise (**Fig 4**).

Fig 2: a) A saddle in balance; b) a saddle that tips backward; c) a saddle that tips forward.

Fig 4: The tree points are too far forward and interfere with the scapulae. The saddle has been positioned too far forward, but even if it was placed further back it tended to slide forward during exercise into this position. The saddle is therefore sitting too close to the scapulae, which rotate backwards during protraction of each forelimb. The proximity of the saddle to the scapulae raises the pommel and lowers the cantle. The front panel and saddle flap of a general purpose or forward cut saddle may overlie the scapulae without causing a problem, provided that the tree points do not impinge.

Fig 5: The tree of the saddle is too long, extending beyond the 18th thoracic vertebra. The position of the 18th rib is indicated by the arrow.

The saddle tree should not extend beyond the top of the last rib (i.e. caudal to the 18th thoracic vertebra, T18). If the saddle is too long it will compromise the function of the middle gluteal and *iliocostalis* muscles (**Fig 5**, **Supplementary Item 3**). It may also impair lateral bending because of pressure on the lumbar transverse processes. The length of the saddle has to be appropriate for both the horse and the rider and fitting both the horse and the rider can be a problem with large riders and also growing children on ponies, especially in horses and ponies with short backs. Growing children may require a longer seat to accommodate a relatively longer thigh. It may be possible to increase the length and/or width of the seat without increasing the length of the tree in order to provide some compromise.

The front of the ventral panels should be parallel to the side of the shoulder. The ventral panels should have uniform contact with the horse's sides. Horses vary in both the width of their back and the angle of their sides, so the width of the tree and the angle of the tree must accommodate this (**Supplementary Items 4** and **5**).

Saddle pads and numnahs

Many riders use a rectangular or square saddle pad (sometimes called a saddle cloth) ± a numnah contoured to the shape of the saddle underneath the saddle ± a gel pad. There is no scientific evidence to support any of the manufacturers' claims about force distribution or shock absorption. Indeed, such pads and numnahs merely occupy space under the saddle and potentially compromise function of an otherwise appropriately fitted saddle (**Supplementary Item 6**). It is crucial when assessing saddle fit that the fit of the combined proposed combination of pads and numnahs is assessed, as described above. Any pad should be contoured at the front so that it ensures clearance of the spinous processes. The position of any straps attaching the front of a pad or numnah to the saddle should be appropriately positioned so that when done up the pad or numnah is not pulled out of alignment. The loop through which the girth straps pass should also be appropriately positioned so that the pad does not become ruckled when the girth is attached or during movement (**Supplementary Item 6**). The pad should be long enough so that it extends beyond the caudal bearing surface of the panels of the saddle. It should be of a sufficiently flexible material so that its edges do not create friction sores. Pads and numnahs are prone to movement with exercise and it is important to check that they remain stationary and do not collapse onto the spinous processes and/or get displaced caudally.

Girth straps and girths

The girth straps should ideally hang vertically, so that the girth also lies vertically. This is influenced by both the position of the girth straps on the saddle and the shape of the horse; the girth will naturally move to the narrowest part of the horse's thorax, which may be further forward than ideal in a horse with a barrel-shaped thorax and abdomen (**Supplementary Item 3**). If the girth is too far forward this will tend to either tip the saddle forward and/or move the saddle forward. The girth should not interfere with the horse's elbows when the forelimbs are retracted (**Supplementary Item 6**). This can be assessed at rest by picking up each forelimb and pulling it backward. The use of a contoured girth, narrower at the elbow regions and wider under the sternum may allow more leeway for elbow movement, and also provide a larger area over which force is distributed. However, the length and width of the girth should be appropriate to the size and shape of the horse (**Supplementary Item 7**). The girth should follow the contours of the thorax and have uniform contact without excessive pressure on either the cranial or caudal margins. With many dressage saddles and close contact saddles, short girths are used with the buckles directly on the horse's side. This removes bulk from under the rider's legs under the saddle flaps; however, this results in direct focal pressure on the horse's muscles. Their position should not be too low in order to avoid interference with the elbow and should be on the widest point of the thorax, approximately at the level of the shoulder.

Girths are available in a number of materials, with or without elastic inserts. Worn elastic may result in the girth being over-tightened or allow excessive/unacceptable movement

of the saddle. Elastic on only one end of the girth may result in the saddle being pulled slightly to one side. Ideally a girth should be fitted centrally so that it is on a similar hole on the left and right sides, to equalise pressures.

The saddle during exercise

Saddle fit must be assessed both statically and when the horse is being ridden to check that it does not move excessively, tip forward or backward or slip to one side (**Fig 6**, **Supplementary Item 8**). The saddle should remain central on the horse's back in walk, trot and canter, with the seat approximately parallel to the ground, and the rider sitting in balance centrally on the middle of the tree. A little movement from side to side is normal, but the saddle should not swing from side to side or lift off the back (**Supplementary Item 8**). If the saddle slips consistently to one side this may reflect an ill-fitting saddle, a crooked rider, asymmetry of the horse's back or, most commonly, hindlimb lameness (see Consequences of an ill-fitting saddle to the horse; **Fig 6**).

If a horse is working correctly, the back dimensions may increase during exercise and the saddle must be able to accommodate this. Inspection and palpation of the horse's back before and after normal ridden exercise are important to identify focal areas of pain, which may reflect force concentration. If the saddle fits correctly, the horse should sweat uniformly underneath the saddle. The hair coat should remain flat. A saddle that appears to fit a horse when standing at rest may not fit when the horse is in correct work posture, with increased tightness of the panels, especially at the twist (the narrowest part of the tree), between the stirrup bars or because of a narrow gullet. This may impair the horse's ability to move not only the spine, but also the scapulae and thoracic girdle.

Fig 6: Saddle slip to the left induced by hindlimb lameness. When the lameness was abolished by diagnostic analgesia the saddle sat squarely. Saddle slip has induced some crookedness of the rider, who sat straight on normal horses.

Saddle fit for the rider

The rider must be able to sit centrally in the seat, not tipping forward or back. The rider's seat bones and thighs should have even contact. The rider's position is influenced by the type of saddle (dressage, jumping, general purpose), the position of the stirrup bars and any knee or thigh rolls and the balance or otherwise of the saddle (**Fig 2**, **Supplementary Item 9**). Irrespective of saddle design, when the rider's legs hang they should not drift forward or backward. The rider should be able to stand in the stirrups and maintain their balance, both when stationary and when the horse is moving. The rider's shoulder, *tuber coxae* ('hip') and heel should remain in the same vertical plane with alignment of centre of gravity of both the horse and the rider to enable the rider to be in balance. The shape, length and width of the seat and the position of the seams between the seat and the skirt (the flap overlying the stirrup bars) and the seat and the sweat flaps all have a huge influence on rider comfort and need to be appropriate for the rider. If the saddle is too wide for the rider it impacts on the orientation of the rider's coxofemoral joints and influences both function and comfort. A saddle that is too narrow in the twist for the rider will cause significant discomfort in the perineal region. Male and female riders sit differently due to different shapes of the pelvis. A saddle designed for a male rider may tip a female rider slightly backward into a 'bucket seat' posture. The alignment of the rider's pelvis and the proximity to the pommel of the saddle also influence comfort of the genital region and must be assessed both with the horse standing still and in motion. The shape and height of the pommel both influence rider comfort. In general terms the length of the seat should allow the rider to place a hand's breadth (i.e. approximately 10–12 cm) between themselves and both the front and back of the saddle.

Recognition of an ill-fitting saddle

Identification of an ill-fitting saddle requires inspection of the saddle off the horse (**Supplementary Items 10** and **11**), on the horse without and with the rider and seeing the horse worked, performing the movements (for example including jumping, cantering downhill) that it might normally be expected to do. The entire bearing surface of the saddle should be inspected and palpated. A saddle with lumpy, uneven or excessively hard flocking is likely to cause discomfort. The presence of depressions in the flocking caused by storage of the saddle on a rack is undesirable (**Supplementary Item 12**). The symmetry of the flocking should be assessed bearing in mind that a saddle fitter may have deliberately flocked or air-filled the saddle asymmetrically in order to accommodate asymmetry of the horse's musculature (**Supplementary Item 13**). Air-filled panels can

become deflated, resulting in inadequate protection from the tree (**Supplementary Item 11**). Feel along the panels and gullet to check that there is complete coverage of the tree.

If the gullet of the saddle is too narrow or too low it will interfere with thoracolumbar function and induce pressure on the spinous processes and pain (**Supplementary Item 8**). If the tree points are too far forward the function of the thoracic sling and movement of the forelimbs may be impaired because of pain (**Fig 4**). This may be reflected by shortened forelimb steps and an unwillingness to work on the bit. A saddle tree that is too long may impair function of the middle gluteal and *iliocostalis* muscles and restrict lateral bending (**Fig 5**, **Supplementary Item 3**). Similarly panels that extend beyond the caudal aspect of the tree, especially if they extend sideways, may restrict lateral bending in some horses. A saddle tree that is too wide may result in the saddle tipping forward (**Supplementary Item 9**). If the saddle tips forward or backward it will result in focal force concentration. If a saddle tips forward it may bounce behind when in motion and may move from side to side excessively, causing torque forces in the mid-thoracic region (**Fig 7**). A saddle tree that is too narrow will result in the saddle tending to perch and create excessive force, especially at the tree points (**Supplementary Item 14**). If the panels do not have even contact with the horse's back, force will be concentrated with the potential to cause pain. A common problem is reduced contact under the centre of the saddle called bridging, with resultant increased forces under the back and front of the saddle (**Supplementary Item 15**).

Consequences of an ill-fitting saddle to the horse

The use of an ill-fitting saddle can have both short-term and long-term implications for the horse. Early warning signs include muscle soreness under the saddle. The horse may flinch when being groomed, or behave abnormally when being tacked up. This may be manifest as the horse moving to the back of the stable when the rider approaches with the tack, the horse fidgeting when being tacked up, putting its ears back, and threatening to bite or kick. The horse may become hypersensitive to touch especially in the withers area and sometimes around the girth. This may in part be due to the phenomenon called wind up. There may be swellings under the saddle panels after exercise (**Supplementary Item 16**). (It should be borne in mind that soft swellings on the dorsal midline that appear transiently after ridden exercise are currently of unknown aetiology. It is curious that these only appear after ridden exercise, although it is difficult to prove an association with saddle fit.) There may be dry patches especially under the front of the saddle surrounded by sweat after exercise, reflecting focal pressure (**Supplementary Item 2**). Dry patches on the dorsal midline surrounded by sweat after exercise could indicate too many layers or too thick a layer beneath the saddle, filling up the gullet and pressing on the spinous processes (**Supplementary Item 17**). If the saddle is moving too much during exercise the hair under the saddle becomes ruffled; this is usually most obvious under the front of the saddle (**Supplementary Item 6**). If the back of the saddle moves excessively, it may physically abrade the skin resulting in scabby skin lesions. Note that the binding on a numnah can create similar lesions.

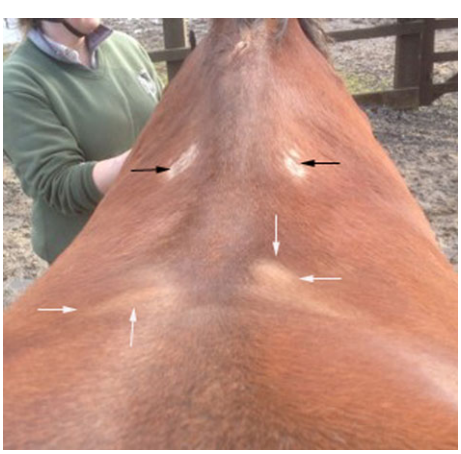

Fig 7: There are focal patches of white hair under the cranial aspect of the saddle (black arrows) reflecting chronic pressure from either the twist of the tree or a gullet that was too narrow. There is asymmetrical hair wear under the caudal aspect of the saddle associated with the saddle slipping to the left. There is a more focal patch of hair wear closer to the midline on the right side, and a more diffuse area of less intense hair wear further away from the dorsal midline to the left (white arrows). If saddle slip is chronic, this will result in asymmetrical distribution of the saddle flocking, which could be misinterpreted as the cause of saddle slip, rather than an effect of saddle slip.

Longer-term indicators of poor saddle fit include muscle atrophy, especially caudal to the scapulae resulting in depressions (**Supplementary Item 2**), or elsewhere under the saddle. These may reflect a chronically poorly fitted saddle and pressure points. Generalised muscle atrophy may reflect back stiffness and lack of proper function as the result of pain induced by the saddle-rider combination. In a young horse, a chronically ill-fitting saddle may compromise back function, resulting in failure of the epaxial muscles to develop properly. Careful palpation may reveal adhesions between the skin and underlying fascia; the skin cannot be moved over the fascia (**Supplementary Item 18**). Alternatively, there may be deeper areas of fibrosis. White hairs appear when pressure (and perhaps heat or friction) has injured the hair follicles. However, these usually do not appear until the hair coat changes. A common site is in the region of the tree points or the twist of the saddle (the narrowest part) (**Fig 7**). Bear in mind that ill-fitting rugs can also result in the development of white hairs, especially on the dorsal midline caudal to the withers. The hair under the saddle may become permanently curly, rather like the hair on limbs that are constantly bandaged. Abnormal movement of the saddle or ill-fitting numnahs may result in abnormal hair wear that may be most obvious in the winter, usually under the back of the saddle (**Fig 7**). Mild symmetrical hair wear can be normal, but asymmetrical hair wear usually reflects abnormal saddle movement. If the saddle constantly slips to the left, either as the result of asymmetry of the horse's musculature, an ill-fitting saddle, a crooked rider or hindlimb lameness, then hair wear will be asymmetrical. There will be a focal patch of intense hair wear close to the dorsal midline on the right and a more diffuse patch of less intensely worn hair further away from the dorsal midline to the left (**Fig 7**, **Supplementary Item 19**).

With respect to the horse's performance, the consequences of an ill-fitting saddle include a restricted forelimb step length, back stiffness, overall shortness of step, unwillingness to bend, and a tendency to become above

the bit. These are obviously nonspecific signs, but their presence indicates that saddle fit should be assessed.

Although the tendency of a saddle to constantly slip to one side, 'saddle slip' (**Figs 6** and **8**), may be the result of an ill-fitting saddle, equine thoracolumbar asymmetry or rider crookedness, the most common cause is hindlimb lameness (Greve and Dyson 2013b, 2014). The presence of saddle slip is not related to the severity of lameness. The presence of saddle slip may actually be an indicator of subclinical lameness. The saddle most commonly slips to the side of the lame or lamer limb, but may slip toward the nonlame or less lame limb, or occasionally to both left and right in bilaterally lame horses. Saddle slip may induce the rider to sit crookedly so that when viewed from behind the rider tends to 'collapse' on the side opposite to the side to which the saddle has slipped, so that the shoulder and *tuber coxae* are lower. Paradoxically, a well-fitted saddle is more likely to slip than one that bridges. Saddle slip induced by lameness is usually much more obvious on one rein, is worst in canter and with a lightweight rider or less-skilled rider, whereas saddle slip induced by major equine thoracolumbar asymmetry may be present on the left and right reins.

Consequences of an ill-fitting saddle to the rider

A saddle that does not fit the horse can compromise equine thoracolumbar function and the resultant stiffening of the horse's thoracolumbar region may induce rider back pain. A saddle that does not fit the rider may compromise their position and balance and induce back and/or hip pain. A seat that is too wide may result in abrasions under the rider's seat bones. A seat that tips the rider toward the pommel, or places the rider too close to the pommel can result in perineal injury in either female or male riders. The more forward inclination of the female pelvis results in them being particularly at risk.

Fig 8: Saddle slip to the left and an inherently crooked rider. The rider's right shoulder is lower than the left; her body has concavity on the right side and the right elbow is lower than the left. Her seat has moved to the left. The right leg is drawn up and the heel is higher than the toe.

Other factors to consider: changes in horses' back dimensions

Horses are not static in their shape. There is evidence that exercise can induce transient increases in the dimensions of a horse's back presuming that the saddle ± pads and numnahs fit appropriately and the horse is working correctly i.e. 'on the bit' (Greve *et al.* 2015). These changes were measured at four predetermined locations: the shoulder (a point one-third of the distance between the point of the elbow and the point of the shoulder), and at the 8th [T8], 13th [T13] and 18th [T18] thoracic vertebrae, at 3 and 15 cm ventral to the dorsal midline. Within a 30 min exercise period the mean dimensions changed between 1 and 1.5 cm (more caudally than cranially). An ill-fitting saddle prevented these changes occurring, which may have long-term consequences for muscle development and performance.

Back dimensions also alter over time. In a longitudinal study of 104 sports horses monitored every 2 months over one year, with measurements acquired at the shoulder, T8, T13 and T18, there were considerable variations in back dimensions over one year (Greve and Dyson 2015a). The presence of gait abnormalities at the initial examination or pre-existing back asymmetry had a negative effect on changes in back dimensions. Subsequent improved saddle fit, similar or increased work intensity, season (summer vs. winter) and increased bodyweight had positive effects on changes in back dimensions (**Supplementary Item 19**). It is therefore concluded that because quantifiable changes in back dimensions occur throughout the year, saddle fit should be reassessed professionally several times a year, especially if there has been a change in work intensity.

The use of the same saddle on more than one horse

Ideally, each horse should have its own custom-fitted saddle. Horses vary considerably in their individual shapes and sizes and for optimal function and performance a well-fitting saddle is crucial. Saddle fit can sometimes be improved by the use of numnahs, pads or shims, but while these may redistribute forces with short-term improvement in performance, this is unlikely to be a long-term solution for a saddle that does not fit.

Some saddles have air pockets that can be filled to mould to the horse's back and thus adapt the saddle to asymmetries of the horse's back. The amount of air can be adjusted to accommodate changes in back shape. Compression of air does not have the same effect as compression of conventional flocking, which may lead to impaction of flocking, and thus the risk of pressure points may be reduced. However, the use of an air-filled saddle is not recommended as a method to adapt a single saddle for regular use on more than one horse. Air-filled saddles

should be professionally adjusted for optimal fit to a particular horse.

Some saddles have an adjustable tree so that the angle at the front can be changed, to accommodate the shape of a particular horse. This is a good option if a horse tends to change shape frequently under the front of the saddle, without changing shape further back beneath the saddle. However, there are data indicating that, if a horse changes shape underneath the front of the saddle, this is often accompanied by changes at the level of the back of the saddle as well (Greve and Dyson 2015a). Changing the width of the front of the tree will not necessarily allow the saddle to follow the shape of the horse's entire back. If only one part of the tree fits well, it is no better than having a saddle in which the whole tree does not fit. It is not easy to adjust the tree quickly and accurately. Buying saddles with adjustable trees to fit many horses is not advisable. They should be fitted and adjusted to a specific horse by a trained fitter.

If a professional yard has more horses than saddles it is recommended that each horse-saddle combination is assessed and each horse should be assigned one of two saddles that provide best fit. This will need to be reassessed periodically.

Pads and numnahs: what is their purpose?

A well-fitted saddle should not need anything underneath it. A numnah or saddle pad (saddle cloth) can be used to keep the bottom of the saddle clean, to carry a sponsor's logo or to change the appearance of the horse's back. The use of pads and numnahs has risen hugely in popularity for no logical reason with respect to thoracolumbar function. A thick numnah or saddle pad can alter the fit of an ill-fitting saddle in a positive way in the short term by altering the distribution of forces, but it is not a long-term solution for the best comfort of the horse. Numnahs and pads can change the balance of a well-fitting saddle and can narrow the space available between the gullet and the horse's spine and restrict muscle function (**Supplementary Item 17**). Adding a pad to a saddle that was already too narrow has a negative effect. Adding a thick pad can unbalance a saddle that is sitting level without a pad. If the balance of the saddle is not to be altered only a thin numnah or saddle pad should be used.

A riser pad elevates the entire saddle, either uniformly, or the front or the back of the saddle preferentially. For example a riser pad that raises the back of the saddle may be used if the saddle slopes down toward the cantle. Alternatively shims (wedge-shaped pads) can be used to selectively raise one part of the saddle. If the saddle slopes backward, shims can be placed under the back of the saddle. Usually these saddles are too narrow or have insufficient depth of gusset at the rear and lifting the back of the saddle improves the balance. However, it may result in the tree points being pushed into the withers. It may increase pressure on the spine and create a large 'bridging' area with reduced contact beneath the centre of the saddle. If the saddle is too wide, shims can be added under the front until the saddle can be reflocked or the tree or panels adjusted. The shim configuration may need to be altered frequently, as often as every month, if the horse is changing shape. Air-filled panels may provide a better solution than temporary shims or riser pads.

A gel pad will not improve the fit of a well-fitted saddle. Promotional materials claim that a gel pad acts as a shock absorber, but there is little scientific evidence to support this. It may limit movement of the saddle to some extent, but this may result in overheating of the back. Gel pads are usually placed over a saddle pad, and beneath the saddle. There are also thin, 'lace-like' gel pads that are specifically marketed as antislip pads and there has been a recent trend, especially for event riders, to place these directly against the skin. These generate shear forces and a lot of heat, usually resulting in extreme back soreness (**Supplementary Items 18** and **20**).

Any numnahs and saddle pads must provide clearance of the spine; it should still be possible to insert 2 fingers' width (i.e. 4 cm) between the numnah and the spine and the sides of the withers with a rider on the horse. The numnah and pad should be of the appropriate shape and size to fit both the horse and the saddle. They are frequently bought without any thought to either of these features. If a pad or numnah is too small, it may create a ridge of pressure at the edge (**Supplementary Item 21**).

Numnahs and pads vary in their construction; some have very firm edges that can create focal pressure points (**Supplementary Item 22**). Some have stitching around the periphery and if this line of stitching is, for example, directly under the back of the saddle this can create friction and pain (**Supplementary Items 14** and **22**). One function of a numnah or pad can be to absorb sweat. It is crucial therefore, that pads and numnahs are washed very frequently to maintain hygiene and softness. Horses' skin may react to biological washing powders, so a nonirritant washing powder should be used.

Other saddle fit accessories

Saddle fit accessories, such as a breast-plate or a crupper may be used to hold a saddle in position in extreme situations, but if required daily to keep a saddle in position, the saddle does not fit the horse properly. A breast-plate should not be used to lock the saddle in position. This may cause a continuous pressure on the chest and shoulder, or the caudal aspect of the scapulae, due to the tree points being held forward and thus restrict the movement of the forelimbs. A breast-plate must be fitted to the horse so that it does not interfere with the shoulder movement.

Other factors that will influence the horse, saddle, rider interaction

Many horses have some degree of left-right asymmetry of the back dimensions, which may be apparent visually (**Supplementary Item 13**), but can be more objectively assessed using a flexible curve ruler contoured to the shape of the horse's back. Marked asymmetry in the shoulder region in particular has a potentially large influence on the position and movement of a saddle and the gullet plate and/or panel flocking of the saddle may need to be adjusted accordingly to accommodate such asymmetry.

Riders may also be asymmetrical. This may be inherent asymmetry or an acquired postural asymmetry. When viewed from behind at all paces a rider should sit so that their shoulders and tuber coxae are level. In a survey of 276 riders, 37% sat crookedly when viewed from behind (Greve and

Dyson 2014) (**Fig 8**). Asymmetry is likely to result in uneven force distribution, which may compromise function of the horse's back. A rider should also be able to maintain a stable position, with the shoulder, 'hip' and heel in alignment, moving in rhythm and balance with the horse. If a rider is not in balance then their weight distribution is likely to compromise equine thoracolumbosacral function.

Rider body size relative to the horse is a potential issue, but is dependent on many factors including the type, speed and duration of work and rider skill and balance (Clayton *et al.* 2015). The veterinary profession is in a position to provide advice concerning rider size and bodyweight relative to horse size and type. Although there are no scientifically validated studies, as a general guide the ratio between rider and horse bodyweight should not greatly exceed 20% (**Supplementary Item 23**).

In a survey of 506 sports horses in normal work, minor thoracolumbar left-right asymmetries (0.6 cm) at T8 and T13 were common and significantly associated with the weight of the rider, the ratio of the weight of the horse and rider and previous rider injuries (Greve and Dyson 2014). This could indicate that the repetitive force applied by a heavy rider with an asymmetric position on the horse is likely to place abnormal stress on the horse's back and contribute to the development of small muscular asymmetries.

Saddle storage and maintenance

Saddles should be cleaned at least weekly to maintain softness and suppleness of the leather. This may be with a damp cloth or sponge using warm water, followed by application of saddle soap and/or a leather food and oil as necessary, or an all-in-one product that cleans and protects leather. How saddles are stored can have a large influence on the contour of the panels. Conventional commercially sold saddle racks usually create grooves on the lower surface of the saddle. Saddles are best stored on an even surface; tubular or V-shaped saddle racks covered with padding may be best.

The prevalence of saddle-related problems

In a UK study assessing 506 sports horses in regular work, 18.4% were ridden in ill-fitting saddles with uneven contact along the length of the horse's back, and in 32.8% the saddle was unbalanced, tipping backward in 20.4% and tipping forward in 12.5% (Greve and Dyson 2014). This presumably reflects that a high proportion of riders cannot detect poorly-fitting saddles and do not recognise the importance of a correctly fitting saddle for both optimal comfort and performance of the horse. In a related UK survey, only approximately 12% of riders had their saddle-fit assessed professionally more than once yearly (Greve and Dyson 2015b). Crooked riders and equine thoracolumbar region asymmetries were associated with ill-fitting saddles, presumably reflecting the uneven force distribution on the horse's back caused by poor sitting posture of the rider and further exacerbated by areas with peak force related to the ill-fitting saddle. Better education of riders, trainers and veterinarians for assessment of saddle-fit is required. Early recognition of an ill-fitting saddle may provide an opportunity to reduce the risk of compromised thoracolumbosacral movement, development of back pain, muscle atrophy and deterioration in performance because of an ill-fitting saddle.

Who is qualified to provide professional advice on saddle fit?

In the UK, the Society of Master Saddlers (www.mastersaddlers.co.uk) provides training courses and examinations for saddle fitters, who should be able to judge the fit of a saddle correctly and provide appropriate adjustments to ensure an ideal fit. However, it is unrealistic to expect that traditionally trained saddle fitters will have an in-depth knowledge of all the different makes and designs currently available. Many commercial companies selling saddles train their own fitters. These people may be well-trained in the fitting and adjustment of their own saddles, but are not necessarily qualified to fit and adjust other makes of saddle. In the UK and Europe the Master Saddle Fitting Consultant Society (www.msfc.nl) provides training courses for saddle fitters that embrace both the horse and rider. In North and South America, Africa, Australia and Europe, Saddlefit 4 Life also provides training courses with a high emphasis on saddle fit for both the horse and rider (www.saddlefit4life.com).

Some physiotherapists provide specialist advice on rider position, providing analyses of rider posture and movement by a series of manoeuvres performed while standing on their feet and then objectively assessing the position of the rider on a mechanical horse. Exercises can be prescribed to address specifically asymmetries in posture, which can compromise equine thoracolumbosacral movement.

Conclusions

Correct saddle fit for horse and rider is an important equine welfare issue and the veterinary profession needs to recognise this and be at the forefront of helping to educate the horse owning public. Ideally veterinarians should work in conjunction with professional saddle fitters, trainers and physiotherapists to improve both horse and rider comfort.

Authors' declaration of interests

S. Carson is a commercial vendor of her own brand saddles and saddle fitter; M. Fisher is a commercial Society of Master Saddlers qualified saddle fitter and vendor of a variety of saddle brands.

Ethical animal research

Not applicable

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Authorship

All authors contributed to all aspects.

Glossary

Cantle: The back of the saddle.

Close contact saddle: The close contact tree is flat with a shallow gullet and therefore sits very close to the horse's dorsal midline. The saddle usually has only one layer separating the rider's limbs from the horse's sides (i.e. no individual sweat flap and saddle flap; monoflap), and therefore uses a short girth.

Flocking: The material that fills the panels – wool, felt, synthetic material, air or a combination.

Gel pad: A silicone-based pad placed under the saddle, usually over a saddle pad, purportedly to provide more comfort for the horse. Some are perforated with holes allegedly to 'make the pad breathable'. Thin lace-like gel pads are also sold that are placed directly on the horse to try to prevent the saddle moving.

Girth: The girth holds the saddle in place, attaching by straps to the left and right sides of the saddle. Girths vary considerably in width, shape and the material(s) from which they are constructed. Traditional girths had parallel sides; many modern girths have contoured margins to provide room for the elbow and a larger bearing surface under the thorax.

Girth guard: A piece of material, usually leather, which can slide up and down the girth straps, designed to cover the girth buckles.

Girth straps (billets): The straps to which the girth is attached; the number and position of straps varies among saddles. The optimal position varies depending on the shape of the horse.

Gullet: A term used variably to describe the area under the pommel or the channel between the panels (panel channel).

Gullet plate or head plate: A plate of steel or synthetic material that forms the front part of the tree, which determines the width of the gullet and the angle of the front panels. In some saddle designs it is adjustable or interchangeable.

Gusset: A term used to describe a wedge-shaped piece sewn in under the ventral part of the front saddle panel (withers or front gusset) or more commonly a wedge-shaped piece sewn in under the caudal part of the saddle, caudal to the saddle flap. The latter can increase the weightbearing area in the caudal panel area and make it flatter than a nongusseted saddle which tends to have a more convex ventral profile.

Half numnah: A numnah that only covers the underside of the dorsal (seat) part of the saddle.

Head plate or gullet plate: A plate of steel or synthetic material that forms the front part of the tree, which determines the width of the gullet and the angle of the front panels. In some saddle designs it is adjustable or interchangeable.

Knee roll: A roll usually on the cranial aspect of the sweat flap, or built into the flap of a close contact saddle, providing support for the rider's leg.

Numnah: A saddle-shaped pad of variable thickness, usually made of sheepskin or synthetic material, placed under the saddle.

Panel: The horizontal panels cover the underside of the tree and provide the interface between the saddle and the horse; the front panels extend ventrally from the cranial aspect of the saddle, covering the underside of the head or gullet plate.

Panel channel: The space between the left and right panels, sometimes called the gullet.

Pommel: The front of the saddle.

Rails: The left and right parts of the tree, covered by the panels.

Riser pad: A pad designed to raise the saddle, either uniformly or more at the front (cranially) or more at the back (caudally).

Saddle pad or saddle cloth: A usually rectangular-shaped pad of variable thickness placed under the entire saddle; a well-designed pad is contoured so that the mid portion sits up under the gullet of the saddle, without causing pressure on the dorsal midline of the horse.

Saddle flap: The layer, usually leather, which overlies the girth straps.

Seat: The part of the top of the saddle on which the rider sits.

Shims: Wedge-shaped pads used to selectively elevate the front or back of the saddle, unilaterally or bilaterally.

Skirt: The short flap that overlies the stirrup bars.

Stirrup bars: The bars from which the stirrup leathers and stirrups are suspended; these are riveted to the tree and in some saddles their length and/or position may be altered to optimise their position for the rider's leg length.

Sweat flap: In a conventional saddle (as opposed to a monoflap saddle), the layer that covers the horse's side, over which the girth straps lie.

Thigh roll: A roll on the caudal aspect of the sweat flap, or in a close contact saddle, built into the flap, to inhibit the rider's legs from moving too far backward.

Tree: The framework of the saddle, formerly made of wood, but now often made of carbon fibre or other synthetic material such as polyurethane.

Tree point: The ventral aspect of the head or gullet plate; in modern saddles they are either straight or directed caudally.

Twist: The narrowest part of the tree and seat of the saddle.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Supplementary Item 1: The tree points were tight and the saddle poorly balanced, sitting high behind; a hand could easily be slid under the caudal aspect of the saddle. During ridden exercise the back of the saddle bounced up and down.

Supplementary Item 2: A dry patch under the cranial aspect of the saddle after exercise (arrows) reflecting excessive pressure. There is also a focal patch of white hair and muscle atrophy. The saddle and pad combination fitted poorly; with adjustments this horse sweated more uniformly.

Supplementary Item 3: Two rather overweight horses with a barrel-shaped thorax and abdomen. a) The girth is pulled forward into the narrowest portion and as a result the saddle tipped and moved forward and bounced behind. The rider used a saddle pad with rubber insets under the saddle, on both the saddle and horse sides of the pad. b) An H-girth has been used to avoid the saddle being pulled forward. The seat of the saddle is long for this short backed horse.

Supplementary Item 4: The concept of tree fit: the angle of the tree points being parallel to the horse's side and of appropriate width for the horse's back. To the left, a correctly fitted tree: the angle of the tree points is parallel to the angle of the horse's side, so that the two green lines are parallel. To the right the tree point angle is more acute than the angle of the horse's side, so the two red lines converge ventrally. In reality the tree obviously sits higher off the horse, covered by the panels, so the fit of a 'bare tree' should be assessed by lifting it 2–3 cm. When assessing a whole saddle the front face of the panel should be parallel with the horse's side. Both the angle of the tree points and their width need to fit appropriately. Two horses could have a similar angle of slope of their sides but differ in width; similarly two horses could be of similar width just behind the withers, but the angle of slope of their sides may differ considerably.

Supplementary Item 5: The concept of width of the tree and angles of the tree points. a) The diagram represents two horses of similar width but different angles of slope of their sides. b) The diagram represents two horses of different widths, but similar angles of slope of their sides.

Supplementary Item 6: a) The girth straps are pulled forwards. The saddle perched, with the combination of the saddle pad and thick half numnah, effectively making the saddle too narrow. The rider felt tipped backward. The girth is also too long and when fully tightened ruckled the edge of the saddle pad. b) As the left forelimb is retracted the point of elbow comes into contact with the girth.

Supplementary Item 7: A contoured girth of inappropriate length and fitting. A hand could be inserted under the front of the girth at the sternum. There was intense focal pressure along the tight caudal margin of the girth and marked pain. The maximum concavity on the cranial margin of the girth is proximal to the elbow. In some horses, this design of girth sits differently when the horse is moving compared with standing still, with the front of the girth coming into contact with the sternal region resulting in a more even pressure distribution.

Supplementary Item 8: A narrow gullet and a tendency of the saddle to move to the right and bounce up and down caudally. The entire back of the saddle raises off the horse's back. The saddle pad does not permit complete clearance of the spinous processes caudally.

Supplementary Item 9: The saddle was tight at the tree points because it is too wide and tips forward. The cantle is high and the seat is very wide (arrow). As a result the small female rider had constant hip joint pain and found it difficult to maintain balance with the horse. The rider may have been

more comfortable if the saddle was balanced correctly.

Supplementary Item 10: The horizontal panels of the saddle are asymmetrically flocked; the left side has more flocking than the right. From the front view the vertical panels are also asymmetrical: the right side was softer and more compressible than the left. The saddle slipped to the right. There was no saddle slip with a more symmetrically flocked saddle. If a saddle is not reflocked regularly an asymmetric rider or horse may induce these asymmetries. Alternatively, the saddle may have been flocked asymmetrically to accommodate previous asymmetry, but not readjusted appropriately. Advice should be sought from a professional saddle fitter.

Supplementary Item 11: This air-flocked saddle is inadequately inflated so that the panel is readily depressed by light thumb pressure resulting in a hard ridge of the tree (arrows), which was pressing into the horse's right side, causing focal pain. The air-flocking had not been checked for >2 years. Air flocking should be soft and is best assessed by applying pressure with the palm of the hand; the thumb pressure here is to highlight how the tree is inadequately concealed.

Supplementary Item 12: Depressions in the flocking of the panels (arrows) caused by storage on a saddle rack.

Supplementary Item 13: Asymmetry of the shoulder musculature which is much more developed on the right side (arrows). The saddle tended to slip to the left.

Supplementary Item 14: The saddle is too narrow so that the saddle perches on the horse's back. The tree points were excessively tight and this is compounded by the saddle pad which has a thick half underlayer, filling the gullet. The saddle bridged. The seat of the saddle tips back. The horse moved more freely with a longer forelimb step length when ridden in a better fitting saddle.

Supplementary Item 15: a) The saddle bridges and tips backward. The saddle pad is too short so that the stitching around the border is under the caudal aspect of the saddle. b) A pad with a sheepskin pad on the underneath, which does not follow the contours of the horse's back. There is no clearance of the spinous processes under the back of the pad.

Supplementary Item 16: a) Focal ruffling of the hair under the cranial aspect of the saddle (arrows) after exercise reflecting movement of the saddle. b) Focal swelling under the cranial aspect of the saddle immediately after exercise reflecting abnormal pressure.

Supplementary Item 17: A saddle, thick pad and numnah that completely pack the gullet of the saddle. The horse was uncomfortable during work and after 30 min of exercise, the dimensions at the level of the eight thoracic (T8) vertebra (arrows) had reduced compared with before exercise (to the left). When the thick pad and numnah were removed the horse worked much better and the dimensions at T8 increased with exercise (photograph courtesy of Line Greve).

Supplementary Item 18: a) A gel pad being used underneath a saddle pad and a half numnah. The saddle was too tight at the tree points, accentuated by the padding. The seat tipped back and the saddle bounced. The saddle moved slightly to the right on the left rein. The horse showed marked resentment of being tacked up. b) The antislip gel pad under saddle was causing shear forces; the fascia under the cranial aspect of saddle was adherent to the skin in the highlighted area (arrows); the area was larger on the right than the left and slightly less close to the dorsal midline, reflecting the slight saddle slip.

Supplementary Item 19: The same horse in March (a) and May (b); the horse has enlarged considerably in back dimensions associated with professional saddle fit in March. Note also the asymmetry of shoulder musculature in May (b), being larger on the left side (white arrow) and the discolouration of the hair in the right caudal saddle region (arrow heads) associated with a tendency of the saddle to move to the right (figure courtesy of Line Greve).

Supplementary Item 20: A large scabby skin lesion in the caudal saddle region the result of a gel pad 'burn'. The area was extremely painful.

Supplementary Item 21: The saddle tips backward; the tree extends beyond the 18th rib. The front face of the panels are not parallel with the horse's side. The saddle is placed on a numnah and a thick half pad which created a ridge under the front panels. The ventral parts of the panels are therefore not in contact with the horse's side. The saddle fitted poorly and the use of half pad has done nothing to improve the situation.

Supplementary Item 22: a) A saddle pad with stiff margins resulting in hair wear on the cranioventral aspect (arrows). The horse was highly reactive to palpation in this region and kicked aggressively. b) Focal swellings and abnormal hair (arrows) under the caudal margin of a stiff saddle pad associated with marked soreness. Such problems may be reduced if owners are advised not to clip the area occupied by the saddle and pads.

Supplementary Item 23: The rider is too large for both the saddle and the horse. Note the way in which the well-fitted numnah follows the contours of the gullet of the saddle. This is the same saddle as Fig 5.