How to Assess the Suitability of Rider Size—Height, Morphology, and Weight—for Optimal Horse Welfare and Performance: A Review

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1. Introduction

As the human population gets larger, there has been growing debate about relative rider-horse sizes and the effect that a large rider may have on equine welfare and performance. The issue of rider weight was highlighted as a priority for research at the 2nd International Saddle Research Trust Workshop.

The following represents a synopsis of recent work that has investigated the potential effects of rider size on equine welfare and performance in horses ridden in English saddles. It is not exhaustive but provides some evidence-based information on which professional advice can be given concerning saddle fit for horses and riders and the size of a rider relative to a horse. In this context, the term rider size is more pertinent than rider weight because the suitability of a rider for a horse is influenced not only by their weight but also by their height and the morphology of the rider’s body. Moreover, rider size is potentially a less sensitive and emotive term, particularly when body mass index of the rider is not in itself a problem. Studies investigating rider weight have been performed, but few have satisfactorily addressed this issue in a typical riding situation. They have, for example, utilized lead weights to alter the total load carried by horses—which does not address the potential differences in physique and balance in riders of differing weights or their position in the saddle—and treadmill exercise, which does not necessarily equate with overground exercise and does not include turns and circles. In addition, several of the previous studies have utilized very high total load:horse bodyweight ratios, or been restricted to walk and trot, and therefore this does not permit determination of whether changes in equine performance may occur at lower rider:horse bodyweight ratios, during all gaits and activities, or permit extrapolation to real-life situations. Therefore, although it is widely recognized that excessive rider size has welfare implications for horses, there has been a lack of reliable scientific evidence on which to base guidelines. This is a multifactorial issue with many interrelated aspects, including the horse’s age; its fitness and muscle development; the length of the thoracolumbar region; the presence or absence of lameness or other musculoskeletal problems; the type, speed, and duration of work; the rider’s skill, fitness, balance, and
2. The Effect of Rider Size and Ridden Horse Gait and Behavior

Two recent studies in more typical riding situations reached somewhat conflicting results on what proportion of a horse’s bodyweight a horse can carry without potential welfare implications. Study A (Dyson et al.), in which four experienced riders, of variable size but of similar ability, rode six horses in random order in a cross-over design, demonstrated that there were adverse effects on both gait and behavior for the two larger riders, ≥ 17% of the horses’ bodyweight. Study B (Christensen et al.) showed no such effects when 20 horses were ridden by their usual riders, without and with additional lead weights strapped to the riders’ torsos, up to 23% of the horses’ bodyweight. This is likely to reflect the differences in methodology employed: Study B added dead weight, which is not the same as mimicking the real-world scenario of Study A, when the distribution of the weight of a large rider (tall and/or heavy) was more difficult to control. Moreover, the duration of riding was substantially different, 5 minutes in Study B versus 30 minutes in Study A. In addition, in Study B, there was a wide spectrum of baseline rider: Horse bodyweight percentages (including tack, 15.3% ± 0.4; range 12–19%) and the average maximum with added lead weights was 18.5% ± 0.5 (range 15–23%). Study A compared the same six horses ridden by four riders (without tack) of 10–12% (L, light), >12 ≤ 15% (M, moderate), >15 ≤ 18% (H, heavy), and >20% (VH, very heavy) of each of the horse’s bodyweight. In both studies A and B, there was no significant effect of rider size on heart rate variables or salivary cortisol concentrations. However, spontaneous blink rate, defined as full occlusions of the left eye by the eyelid, recorded for 15 minutes, was significantly increased postexercise for rider H (p = 0.03; t = 0, df = 5, paired t test; Fig. 1) in Study A. Spontaneous blink rate is an indicator of dopamine function, and an increase reflects a stress response. A Ridden Horse Pain Ethogram (RHpE) has been developed, comprising 24 behaviors, the majority of which are at least 10 times more likely to be seen in a lame horse than a nonlame horse. An RHpE score of ≥8 of the 24 behaviors is likely to reflect the presence of musculoskeletal pain, although some lame horses score <8. Reduction in the RHpE scores after abolition of lameness using diagnostic anesthesia proves a causal relationship between these behaviors and musculoskeletal pain. The RHpE scores can also be influenced by rider weight distribution and saddle fit for the horse (specifically tight tree points of the saddle). In Study A, there was a significant difference in RHpE scores according to riders (Fig. 2; analysis of variance (ANOVA), Bonferroni: M to H, p < 0.01; L and M to VH, p < 0.001; H to VH, p < 0.05) and a linear positive correlation between rider weight and the RHpE score (R = 0.4, p < 0.01, Spearman; Fig. 3). The number of behavioral markers reflecting head position (ANOVA, p < 0.001, F = 17.27; Fig. 4) and facial expression (ANOVA, p < 0.001, F = 18.72; Fig. 5) significantly increased with the H and VH riders.
whereas body markers (head and tail movement) and gait markers had nonsignificant increases. However, the total RHpE scores were less than 8 for the majority of tests. There were predefined criteria for test abandonment: 1. Development of lameness grade ≥ 3/823 in one limb or grade ≥ 2/8 in ≥ 2 limbs; 2. Exacerbation of pre-existing grade-1 lameness by ≥ 2 grades (≥ 2); and 3. An RHpE score ≥ 10/24.13 One test for the heavy rider was halted prematurely because of the display of a total of 10 behaviors of the RHpE by the conclusion of the first canter and all the other tests of the heavy rider, and all tests for the very heavy rider were abandoned prematurely because of the development of transient forelimb or hindlimb lameness. In Study B, a narrower range of behaviors was assessed, which were less specifically defined.14 No effect of rider weight on behavior was seen, but the large variation in the frequency of so-called “conflict behaviors” (e.g., mouth open, tail swishing, head tossing) among the horses before addition of extra weight and the high frequency of tail swishing may have concealed any effect of rider weight. In a third study, there were effects of additional weight on gait, although overt lameness was not observed.11 Eight Icelandic horses carried 20%, 25%, 30%, and 35% of their own bodyweight (a single professional rider plus lead) at the tölt on a 321-m oval track. Kinematics were measured using a high-speed camera in an incremental exercise test (5 × 642 m). Although there were no measurable changes in regularity of rhythm or symmetry, increasing weight was associated with decreased stride length, increased stride frequency, and increased duty factor (the proportion of the stride time during which a limb is in the stance phase) in all limbs, factors that were not assessed in the previous studies. Force is the product of mass and acceleration, so any effect of added weight is likely to be greater at faster than at slower speeds. These observations emphasize the need to consider the expected stride and gait characteristics for the type of horse that is being ridden.

3. Rider Size and Weight Distribution

Rider size, both height (also influenced by limb length versus trunk length) and seat size, and the design, fit, and balance of a saddle determine how a rider sits in a saddle. For optimal weight and force distribution, the rider should sit in the middle of a saddle to enable them to be in balance with the horse and as close as
possible to the horse's center of gravity. In a pilot study, the seat of the rider was too large for the saddle in 41% of 34 horse-rider combinations. In a more recent study, the seat of the rider was too large for the saddle in 40% of 193 horse-rider combinations, and 51% of riders sat on the back rather than in the middle of the saddle. This may have been because the saddle was too small relative either to the rider's leg length or to the size of their seat. Alternatively, it could have been the result of the saddle being the wrong shape for the rider, the stirrup bars being in an inappropriate position, or the rider being in an inherently poor position. In Study A, the heavy and very heavy riders sat on the caudal third of the saddle (Figs. 6, 7). This was in part related to the tall height and long leg length of the heavy rider. It is notable that the usual rider of Horse 2 was of similar weight (91 kg) to the heavy rider (92 kg) but was considerably shorter. When ridden by the usual rider, who sat in the middle of the saddle, the horse performed completely normally; when ridden by the tall rider (H), who sat on the back of the same saddle, the horse showed transient lameness and the RHpE score increased. It was objectively demonstrated in Study A that the larger riders (H and VH) who sat on the back of the saddle increased forces transmitted through the caudal half of the saddle. Pressures were significantly higher under the caudal aspect of the saddle compared with cranially for rider VH in walk ($p < 0.05$, ANOVA, Bonferroni). At rising, trot pressures were higher cranially for riders L, M, and H ($p < 0.05$, ANOVA, Bonferroni) but were similar cranially and caudally for rider VH. The highest maximum peak pressure was recorded for rider VH in canter. For the longitudinal (cranio-caudal) center of pressure (COP), rider VH had a median COP significantly more toward the caudal aspect of the saddle compared with all other riders ($p < 0.01$, $F = 3.2$, ANOVA). Alteration in the cranio-caudal distribution of pressure has the potential to adversely affect thoracolumbar movement and hindlimb gait. In a small study that compared a standard-fitting saddle to one with panels that were 10 cm shorter, there was increased pressure under the middle and caudal thirds of the saddle panels and caudal displacement of the COP with the shorter saddle. This was associated with reduced range of motion in the caudal thoracic and lumbar regions and reduced hindlimb protraction. These effects could be potentially compounded if other saddle-fitting problems were also present. In a study of 191 horse and rider combinations, 49% of riders were observed to be out of balance; 19% of saddle seats tipped backwards, and many of the saddles moved excessively during ridden exercise (dorsosventral 47%, side to side 48%, saddle slip 45%). In a related study comprising a subset of 148 of the horses, there was a significant positive association between RHpE scores for horses ridden by riders who sat on the caudal third of the saddle compared with those in the middle of the saddle.

4. Rider Size, Epaxial Muscle Tonicity and Pain, and Thoracic Dimensions

In Study A, the thoracolumbar region was palpated systematically before and after each ridden test, and the presence and location of epaxial muscle hypertonicity or pain were recorded. Increased muscle tension was defined as muscle stiffness with little or no
yield of the tissue to moderate pressure, which was sometimes also combined with muscle contraction or fasciculation. Pain was characterized by the horse moving away from the pressure or fidgeting, laying the ears back, swishing the tail, kicking, reactive contraction of the muscle, or extending the thoracolumbosacral region. Overall muscle hypertonicity scores (present/not present) for all horses increased significantly for riders M and H after ridden exercise ($p < 0.05$), and for rider VH, there was a trend for increased pain scores ($p = 0.08$), despite early termination of all tests for the heavy and very heavy riders. The thoracic dimensions were documented before and immediately after each ridden exercise test at the 6th, 19th, and 18th thoracic vertebrae using a flexible curve ruler. For each level, the thoracic widths were measured at 5 cm and 15 cm ventral to the dorsal midline, as previously described. It has previously been demonstrated that there are measurable increases in thoracic dimensions after a 30 minutes’ work period, assuming that the horse is working correctly, in a well-fitting saddle. In Study A, there were significant reductions ($p = 0.02$) in thoracic dimensions during a 30 minutes’ work period for the heavy and very heavy riders (H $-3.4\%$ and VH $-2.8\%$, respectively; Fig. 8), whereas for the lighter riders, there were increases in thoracic dimensions (L $3.9\%$ and M $1.9\%$, respectively). The changes were largest at 5 cm ventral to the dorsal midline at the 8th and 13th thoracic vertebrae. The reductions were greater for the heavy rider than the very heavy rider, presumably related to the duration of riding. Tests for the very heavy rider were terminated earlier (mean test duration of 8.3 minutes, range 9–25 minutes) than for the heavy rider (mean test duration of 16.6 minutes, range 6–19 minutes). The reductions in thoracic dimensions could have deleterious consequences for long-term epaxial muscle development and function and may result in atrophy of longissimus dorsi in the thoracolumbar region. These factors could be compounded if the rider sat crookedly, was not in synchrony with the horse’s movement, or if the saddle did not fit the horse ideally, which is a common finding. Ill-fitting saddles were identified in 78% of 193 sports and leisure horses in the United Kingdom, with tight tree points (67%) being the most common problem. In a previous United Kingdom study, ill-fitting saddles were identified in 43% of 205 sports and leisure horses. In Switzerland, 74% of 237 sports and leisure horses had ill-fitting saddles.

5. The Fit of the Saddle to Both the Rider and the Horse

It is generally accepted that the tree of the saddle should not extend beyond the 18th thoracic vertebra (T18), or last rib, although the ability of saddle fitters to identify these landmarks reliably was limited, and agreement among saddle fitters about appropriateness of saddle length was poor. The scientific basis for the principle of the tree not extending beyond T18 is limited, and the Society of Master Saddlers has advised that the panels of the saddle can extend to the first lumbar vertebra. However, if the rider’s weight is centered caudal to the 13th thoracic vertebra, the rider will be positioned behind the horse’s center of gravity, which potentially influences the rider’s ability to be in balance with the horse. There is a significant body of evidence that demonstrates that if a rider is sitting on the back of the saddle, rather than in the middle, this is potentially detrimental to the horse. With some riders, it may be possible to alter the rider’s position by using a saddle that is better suited to their size and that also fits the horse. The seat of the saddle and the panels can be lengthened without increasing the length of the tree. The position of the bars of the saddle, from which the stirrup leathers and stirrups are suspended, can be altered. The shape, position, and size of both the saddle flaps and the knee blocks can be adjusted. However, with some horse-rider combinations, it may be impossible to have a saddle that fits both the horse and the rider optimally (Figs. 9A, B).

6. Overall Considerations: How to Assess Rider Suitability for a Horse

There is sufficient evidence to indicate that a rider who is too large for a horse has the potential to have an adverse effect on the horse’s gait, performance, muscle development, and long-term musculoskeletal health. However, rider size cannot be considered in isolation. There are many other factors to consider—for example, the skill, core strength, balance, and fitness of the rider; the physical well-being of the horse, its fitness and musculoskeletal strength, and its coordination; the duration and intensity of work; and the terrain and footing. Although it has been suggested...
that fit, appropriately conditioned Arab endurance horses are able to carry 20–30% of their bodyweight for 160 km, there is currently insufficient knowledge to give a categorical upper rider:horse weight ratio, beyond which riding is unacceptable. Increasing horse body weight to reduce the ratio is not an appropriate solution. There are, however, some broad guidelines to consider with respect to rider size based on the scientific data presented. The horse’s thoracolumbar length must be able to accommodate a saddle that allows the rider to sit in the center of the saddle, with their shoulder, “hip,” and heel in vertical alignment, and to ride in balance with the horse. An equine veterinarian should be able to evaluate thoracolumbosacral epaxial muscle development, tonicity, and pain, both before and after ridden exercise; to assess static and dynamic saddle fit for the horse and rider; to understand the basic concepts of correct rider position, straightness, and balance; to observe and understand the behavior of horses during tacking-up, mounting, and ridden exercise; to pay particular attention to head and neck position and facial expressions; and to recognize alterations in gait in trot and canter, including shortening of the stride. Comparison of the horse’s behavior and the quality of the movement (step length, limb flight, suspension, rhythm, speed ± lameness) in trot and canter on the lunge without the rider and when ridden (Fig. 9, A and B) may be valuable. During ridden exercise, the horse should be viewed from the side, behind, and in front to assess not only the horse’s movement but also any side-to-side oscillation of the saddle, dorsoventral movement of the back of the saddle (“bouncing”), or saddle slip to one side and whether the rider is crooked. It may be helpful to acquire video recordings so that the observations can be discussed with the rider, together with the implications of those findings with respect to the long-term musculoskeletal health of the horse. When discussing the biomechanical implications of an oversized rider, it should be borne in mind that at walk, the maximum forces transmitted through the panels of the saddle are continuous, whereas at trot they are biphasic. In the three-beat canter, not only are peak forces higher because force is the product of mass and acceleration, but they are also asymmetrical, reflecting the movement of the thoracolumbar region. If the horse is used for jumping, it should be pointed out that the forces under the front of the saddle at landing are considerably greater than those experienced at walk, trot, and canter. Use of a force mat to quantify the distribution, magnitude, and symmetry of forces under the saddle provides some limited objective information. There is a positive association between rider weight and magnitude of force, although it is not a linear relationship. However, it must be borne in mind that what looks wrong probably is wrong (Fig. 9, A and B), and the potential consequences need careful discussion with the rider. Knowledge of the scientific evidence supporting the potentially adverse effects of a rider who is too big for a horse provides a foundation on which to base discussions with an owner. Involvement of an experienced human physiotherapist, as an independent expert who is able to assess rider static and dynamic symmetry, balance, and coordination, is sometimes also helpful.

7. Conclusions
Veterinarians, riders, and trainers should be more aware of the potentially deleterious effects of a rider who is too large for a horse, with respect to gait, thoracolumbar muscle function, and development, and the
potential risk of musculoskeletal injury. They should also recognize that behavioral abnormalities that are often considered as “normal horse behavior” may reflect musculoskeletal pain. Observation of a horse’s behavior during tacking-up and mounting and during ridden exercise may be key indicators that the horse is uncomfortable during ridden exercise.25-42 Comparison of spontaneous blink rate before and after exercise may also be helpful because an increased rate after exercise is an indicator of stress. There is no doubt that for some horse and rider combinations, it may be impossible to find a saddle that is suitable for both the horse and the rider, and in these cases, this means that the rider is likely to compromise the horse’s long-term welfare if they continue to ride. There is a moral responsibility for the equine veterinary profession to advise such riders that they are too large for the horse, however difficult that discussion may be; to fail to do so would jeopardize the horse’s short-term and long-term welfare.

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Declaration of Ethics
Studies performed by the Author and colleagues were approved by the Clinical Ethical Review Committee of the Animal Health Trust. The horse owners gave informed consent for inclusion of their horses in the studies. Principles of Veterinary Medical Ethics of the AVMA were adhered to.

Conflict of Interest
The Author has no conflicts of interest.

References


