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Impact of riding in a coercively obtained Rollkur posture on welfare and fear of performance horses

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ABSTRACT

Rollkur, the usually coercively obtained hyperflexion of the horse's neck, is employed as a training method by some dressage riders; however, its use is controversial as it may cause discomfort and adversely affect the horse's welfare. The objectives of this study were to determine: (1) if horses showed differences in stress, discomfort and fear responses as measured by heart rate and behaviour when ridden in Rollkur (R) obtained by pressure on the reins compared to regular poll flexion (i.e. with the nose-line being at or just in front of the vertical; N), and (2) if they showed a preference between the two riding styles when given the choice. Fifteen riding horses were ridden 30 times through a Y-maze randomly alternating between sides. Riding through one arm of the Y-maze was always followed by a short round ridden in R, whereas riding through the other arm was followed by a short round ridden in N. Immediately after the conditioning phase, horses were again repeatedly ridden into the maze; however, riders left it to the horse to decide which arm of the maze to enter. During R, horses moved slower and showed more often behavioural signs of discomfort, such as tail-swishing, head-tossing or attempted bucks ($P < 0.05$), and 14 of the 15 horses chose significantly ($P < 0.05$) more often the maze-arm associated with N rather than R. Subsequently, eight of the horses were also subjected to two fear tests following a short ride in N as well as a ride in R. During R, horses tended to react stronger ($P = 0.092$) to the fear stimuli and to take longer ($P = 0.087$) to approach them. These findings indicate that a coercively obtained Rollkur position may be uncomfortable for horses and that it makes them more fearful and therefore potentially more dangerous to ride. Further studies need to assess horses' reaction to gradual training of Rollkur, as opposed to a coercively obtained hyperflexion, in order to decide whether the practice should be banned.

1. Introduction

Worldwide, large numbers of horses are used for riding, but the impact of riding itself on the horses' welfare has received comparatively little attention. Given the high potential for welfare implications due to coercive riding techniques (i.e. the use of force, as opposed to gradual training, to achieve certain postures and

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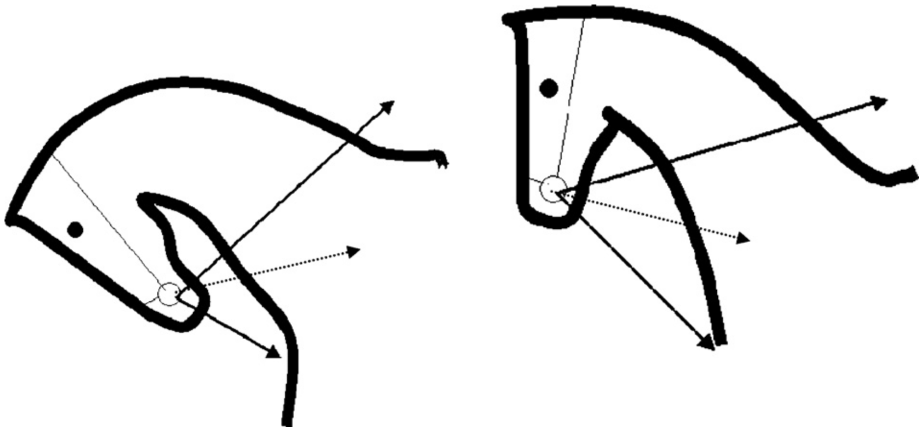

Fig. 1. (a) Horse in Rollkur. (b) Horse in regular poll flexion. Sketches show the horse equipped with draw reins (draw reins are attached to the saddle girth underneath the horse's chest, are led between the front legs through the ring of the bit and from there to the rider's hands.) Arrows indicate direction of force imposed by the rider (top arrow), the fixation point (bottom arrow), and the resulting mechanical force (dotted arrow) that draws the horse's muzzle towards its chest.

movements in the horse) and devices commonly used during riding, such as bits, spurs and whips, research in this area is warranted.

Recently, concerns have been raised, e.g. by the International Equestrian Federation (FEI) about the controversial Rollkur posture, or hyperflexion, which is used in dressage training with the intention of making horses supple. Rollkur involves the positioning of the head and neck in a deep and round position with the horse's muzzle (almost) touching its chest (Fig. 1a), which is usually achieved by applying pressure on reins with or without additional draw reins. The practice of Rollkur is currently being reviewed by the FEI because it is thought to have possible detrimental effects on the physical and/or psychological state of the horse (FEI, 2006). During FEI's (2006) workshop on Rollkur, several speakers pointed out that presently no evidence exists that Rollkur causes long-term physical damage. For example, no deformation of vertebrae was found in two horses that had been trained in Rollkur over a period of several years (Welling, 2006). Moreover, it was argued that Rollkur may be beneficial for training as it is thought to have positive effects on locomotion by decreasing stride length and increasing elasticity (van Weeren et al., 2006). Contrary to this, however, Denoix (2006) pointed out that hyperflexion places stress in the intervertebral discs, in the nuchal area and the withers that may cause, if not lesions, pain in horses with pre-existing conditions, such as cervical lesions. In addition, several researchers have highlighted possible detrimental effects of Rollkur on the psychological state of the horse. According to Heuschmann (2006), Rollkur contains an aggressive component that may have a negative effect on a horse's movement and care should be taken not to confuse Rollkur with the acceptable, less extreme and established low, deep and round posture that is widely used, e.g. in warm-up riding. Ödberg (2006) also suggested that coercive riding may be linked to so-called wastage, i.e. euthanasia/slaughtering of horses unfit for riding or sport due to physical and/or behavioural problems.

In the scientific literature to date, only two studies attempted to investigate the effects of Rollkur on horse welfare. van Breda (2006) found no difference in heart rate variability of elite horses following training bouts in Rollkur and recreational horses ridden in regular poll flexion (Fig. 1b), and so claimed that there were no signs of stress in elite horses ridden in this style. Conversely, Sloet van Oldruitenborgh-Oosterbaan et al. (2006) found higher heart rates and blood lactate concentrations in school horses (used in riding lessons to teach a variety of riders) during a low, deep and round posture used as an approximation of Rollkur, compared to riding in a natural posture with light rein contact. They reported that subjective observations suggested improvement of movement and, since there were no signs of uneasiness in the horse, they concluded that higher heart rates were a sign of higher workload during "Rollkur" (Sloet van Oldruitenborgh-Oosterbaan et al., 2006), which in fact, however, was the low deep and round posture.

Rollkur severely restricts the horse's vision in the direction of travel (McGreevy, 2004), and has also been suggested to disturb the horse's balance (Ollivier, 1999; Karl, 2006), both of which likely have psychological implications. Since the primary objective of dressage is to develop the horse into a "happy athlete" (FEI, 2007), the psychological well-being of a riding horse should be a key focus. The current body of literature that has examined the effects of Rollkur and related issues has focused on physical damage or physiological stress measurements only and has not examined the possible psychological effects that may occur. This is a problem since psychological stress measures are highly confounded with physical exertion (e.g. Perna et al., 1997), which is difficult to control for when investigating issues involving riding as previously described. Compared to physiological measures, motivational and preference tests can provide more direct insight into how an animal perceives certain conditions or treatments. These tests have been used successfully, e.g. with poultry (Dawkins, 1977; Nicol, 1986; Millman and Duncan, 2000), cattle (Pajor et al., 2003), swine (Spinka et al., 1998), and in a few instances horses (e.g. Pickerel et al., 1993; Lee et al., 2001; Müller and Udén, 2007). The present study is the first on welfare implications of Rollkur to use an integrative approach combining cognitive, behavioural and physiological measures.

The aim of this study was to investigate whether or not horses perceive a coercively obtained Rollkur posture as aversive and how it might affect stress and fear responses in horses. Furthermore, the aim was to validate a number of behavioural measures as signs of discomfort and/or stress. The hypotheses of this experiment were: (1) horses perceive Rollkur as aversive, and will avoid being ridden in this technique if given the chance, (2) horses will experience more stress and have higher heart rates during Rollkur than regular poll flexion, (3) horses will show higher levels of behaviour indicative of discomfort or loss of balance, such as head-tossing or stumbling during the non-preferred riding style, and (4) horses will be more fearful during Rollkur, as opposed to regular poll flexion.

2. Materials and methods

All procedures were approved by the University of Guelph's Animal Care Committee, as well as the Research Ethics Board, and are in accordance with Canadian Council for Animal Care guidelines.

2.1. Animals

Fifteen horses were enrolled in the study. Horses were either privately owned ($n = 6$) or used as schooling horses ($n = 9$) to teach riders in a college riding program. Four of them were mares and eleven geldings, ranging between 6 and 23 years of age. They were all warmblood-type breeds, with five of the horses mainly used for show-jumping (J), six mainly used for dressage (D) (up to the Grand Prix level), and four were familiar with both dressage and show-jumping (M). Both dressage and show-jumping horses were chosen to allow comparisons between horses that were accustomed to stronger (D) and lesser (J) degrees of poll flexion. According to the owners, none of the horses had previous experience with Rollkur. All horses were kept in boxstalls with daily riding and/or paddock turn-out for 1–3 h.

2.2. Riders and facilities

Seven highly skilled riders rode the horses (maxima of four horses/rider) in the experiment. Riders either owned the horse they were riding or were otherwise familiar with it from riding lessons, either as a rider or instructor. Testing was conducted at two equestrian centres, one in Ontario, Canada ($n = 5$ horses), the other in northern Ohio, USA ($n = 10$ horses). A Y-maze built of corrugated plastic sheets was set up in the middle of the 20 m × 40 m indoor arenas such that horses could enter the trunk of the maze from a long side of the arena, and leave it through either arm to reach one of the arena halves (Fig. 2). The trunk of the maze measured 2.5 m (length) × 1.25 m (width), the arms were 1.25 m long, and the walls were 1.25 m high, allowing horses and riders to see over the top. The walls of the trunk were blue, whereas the walls of one arm of the maze were black and of the other arm light beige, with the possibility to switch the colours between right and left sides. These colours were chosen as horses are known to be able to discriminate them (e.g. Macuda and Timney, 1999; Geisbauer et al., 2004; Hall, 2007) and in order to provide, in addition to side (left or right), a cue for discrimination of the treatments.

2.3. Conditioning and observation phase

Horses were groomed, saddled and warmed up according to routine management. In addition, electrodes of a heart rate monitor (Polar Equine S810i, Polar Electro OY, Kempele, Finland) were placed underneath the saddle. Water and electrode gel (Spectra 360, Parker Laboratories, Inc., NJ, USA) were used to improve conductivity of the hair and adhesiveness to the skin. In addition to the regular reins, draw reins that redirect forces and reduce the forces required by the rider according to the physical principles of a lifting tackle (Fig. 1) were attached to assist riders in achieving the Rollkur postures in the horse. In order to standardise the treatments within horses, horse-individual marks were placed on the draw reins, indicating to the rider the necessary length to achieve each treatment. For the rider to bring the horse into the Rollkur posture, this length corresponded with extreme neck flexion, such that the horse's muzzle almost touched its chest. However, to address concerns for animal welfare and rider safety, the Rollkur position was adjusted temporarily for brief moments into a less extreme posture until the horse had calmed down again (seven horses) or permanently for the entire testing phase (four horses) if the horse displayed behavioural indicators of acute anxiety, such as vigorous backing up or rearing (cp. McGreevy et al., 2005). Since all animals, including those with adjustments to the rein lengths, maintained a hyper-flexed posture with their noseline clearly behind the vertical and within the range of Rollkur, data from these individuals were not treated differently from individuals that achieved the most extreme Rollkur posture. For the control treatment, the draw reins were marked for a rein length consistent with regular poll flexion, such that the horse's nose was at or just in front of the vertical, as required during dressage tests.

Horses were conditioned and tested individually. During the conditioning phase, the rider rode the horse into the trunk and out of the maze-arms. The order of maze-arms was pre-determined using a semi-randomised procedure of 15 pairs of rides with the first maze-arm (left or right) in the first ride of the pair being determined randomly, but the second ride being assigned the other maze-arm. This procedure was chosen to avoid long sequences of exclusively riding to one maze-arm while still ensuring randomness and equal numbers of rides per maze-arm. Leaving the maze through one arm was always followed by one 20 m circle ridden in regular poll flexion, whereas leaving the maze through the other arm was always followed by one 20 m circle ridden in Rollkur. After each circle, the rider rode again into the maze until they completed 30 circles (15 per treatment), which took in total 20–30 min per horse. The horses were ridden either in clockwise direction (for the first eight rides through the right arm and the last seven rides through the left arm) or counterclockwise direction (for the first eight rides through the left arm and the last seven rides through the right arm) and either in walk (for the first two rides in each treatment and in each clockwise/counterclockwise direction) or trot (for the remaining 13 rides). Therefore, the sequence for each treatment was:

Two circles walk, six circles trot, change in direction, two circles walk, five circles trot.

If a horse was known to have a side preference during riding ($n = 3$, as expressed by reluctance to bend into a turn of the opposite direction), the weaker side was assigned to be associated with regular poll flexion for these horses, but overall, association of maze-arms and colours with treatments was balanced across horses (with the exception of a 16th horse that had to be removed from the study prior to testing due to extreme fear reactions to the maze itself).

2.4. Preference test

Immediately following the conditioning phase, the horses were given the choice between the two riding styles to test for their preference. As previously, the rider rode the horse into the maze, stopped, gave the horse loose reins and signalled the horse to move forward. However, in the test situation the rider did not indicate a direction (left or right). Instead, the riders were instructed to distribute their weight evenly in the saddle, while relaxing legs and back and looking down at the pommel, thereby minimising their influence on the horse and leaving the horse to decide which maze-arm to leave the maze through. During this procedure, horses and riders were observed from behind in order to ensure that the horse stood straight in the maze and to detect and correct potential lateral misbalances in the rider that could influence the horse's choice of direction. This set-up with riders remaining mounted during the preference test was chosen in order to minimise both stress due to frequent remounting (cp. Keil, 2008), as well as unintentional influence of handlers on the horse while leading the horse into the maze. According to the choice the horse made, the rider rode the horse in one circle in the respective style (N or R) in alternating directions. This procedure was

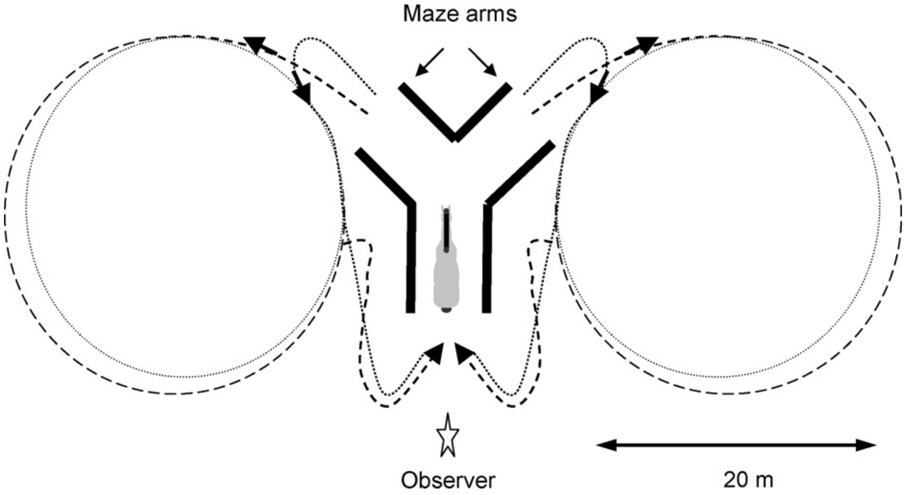

Fig. 2. Plan of the Y-maze. Lines with arrows indicate the direction for the first 16 (dashed line: – – –) and last 14 (dotted line: · · ·) circles and the path (20 m circle and re-entering of Y-maze) along which the horse and rider proceeded during conditioning and preference testing.

repeated until significance for a horse's preference was reached according to the diagram developed for sequential medical testing by Bross (1952). The minimum number of trials with this method is eight times per horse, but depending on how consistently the horses chooses a specific maze-arm this number can be as high as 58 trials to obtain a significant result ($P < 0.05$). However, as a minor adaptation to this procedure the maximum number of trials was set to 35 to prevent overexertion in rider and/or horse.

2.5. Fear test

One to 3 days subsequent to preference testing, the four D and the four J horses from equestrian centre in Ohio were subjected to two fear tests in a balanced order: (1) the sudden exposure to a novel object (a fan blowing air into plastic strips tied to it (F)) or (2) a looming stimulus (an umbrella that was slowly and continuously opened and closed by the observer (U)). Horses were prepared as described above in Section 2.3, and then ridden in 10 20-m circles (five in each direction) continuously in one treatment (N or R). At the end of that riding bout, the horse was exposed to the first fear test. While maintaining the treatment, horses were ridden in walk along a visual barrier, such that the fear stimulus came suddenly into sight when the horse reached the end of the visual barrier (Fig. 3). After the initial reaction, the rider turned the horse towards the stimulus and, following a path delineated on the ground with two poles, encouraged the horse with her riding aids to approach the fear-inducing stimulus starting at a distance of 5 m. The test was terminated after 3 min or when the horse touched the fear stimulus. After completion of the first fear test, the horse was ridden in the other treatment and then exposed to the second fear test (i.e. the other stimulus). Order of treatments and type of fear stimulus were balanced across horses and disciplines (D/J). The set-up with a screen partially hiding the fear stimulus was chosen to ensure equal visibility of the stimulus during the Rollkur and the regular posture, as the Rollkur posture constrains the horse's visual field towards the front, but not laterally (cp. McGreevy, 2004).

2.6. Data collection

Horses' heart rates were recorded continuously (beat to beat intervals) during all experimental stages, using heart rate monitors. Values outside the physiologically realistic range 40–240 bpm (e.g. Clayton, 1991) were considered erroneous and were deleted. Start and end time of each conditioning round, the rides prior to the fear test, as well as the fear test itself were recorded. Average heart rates were calculated for the duration of each individual round, the riding bouts prior to the fear test, during the 15 s immediately following the encounter with the fear stimulus, and during the duration of the approach to the fear stimulus. In addition to horses' treatment choices in the preference test, behavioural responses to the two riding treatments were assessed during the conditioning phases. Behavioural observations were taken by a trained observer standing on the right side of the maze trunk during the conditioning phase. The frequency of occurrence of the behaviour patterns as outlined in Table 1 was recorded. These behaviour patterns were chosen as they have been suggested to be signs of discomfort, conflict (between motivation to follow the rider's aids and fear of executing the requested movement), frustration or resistance to rein pressure (e.g. Waring, 2003; McGreevy et al., 2005). Behavioural observations were taken during the fear test to assess strength of reaction at first encounter of the stimulus on

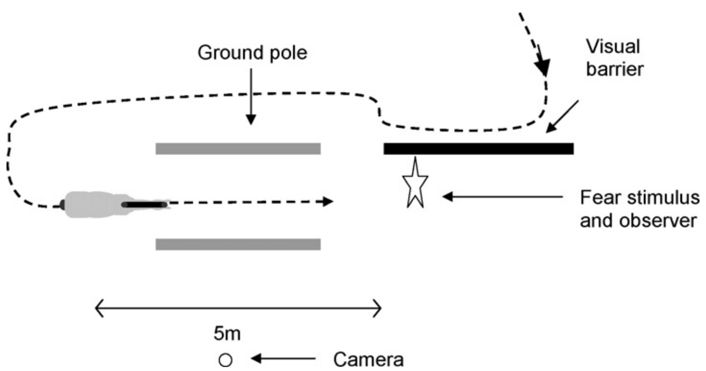

Fig. 3. Overview of the fear test showing the position of the fear stimulus, observer, visual barrier, ground poles, camera and the path ridden by the rider (dotted line).

Table 1
Description of categories of behaviour observed during the conditioning phase, and their reference to literature suggesting these types of behaviour to be signs of stress, discomfort, frustration or conflict.

Behaviour category	Description
Change in pace	The horse either attempts to stop moving forward (McGreevy et al., 2005) or shows bouts of trot/jog (during walk) (McLean, 2005) or canter (during trot)
Bouts backing up	The horse walks backwards rather than forward (McGreevy et al., 2005)
Crabbing	The horse moves sideward–forward such that the hind legs of the horse travel on a line beside the front legs, rather than in a straight line (McGreevy et al., 2005)
Attempted bucks	The horse suddenly arches the back while jumping upward–forward movement, and usually with ears laid back (McGreevy et al., 2005)
Stumbling	An interruption of the gait-specific, rhythmic footfall with loss of balance
Tail-swishing	Quick, lateral movement of the tail (McGreevy et al., 2005)
Head-tossing	The horse attempts to move the head in a quick forward–upward motion (Minero et al., 2003) that is usually restricted by the reins held by the rider (Waring, 2003)
Nose tilting	The horse tilts its nose to one side (McGreevy et al., 2005)
Abnormal oral behaviour	The horse opens the mouth for extended periods (>5 s) of time or grinds its teeth (McGreevy et al., 2005)
Snorting	The horse exhales air forcefully (Waring, 2003) (however, snorting has also been suggested as a sign of comfort by Fraser, 1998)
Groaning	The horse makes a grunting noise (Waring, 2003)
Visibility of eye-white	The horse shows the white of the eye for extended (>5 s) bouts (Sandem et al., 2004 in cows)
Ears fixed backward	The horse turns its ears backward (but not entirely flattened) and keeps the ears fixed in this position for extended (>5 s) bouts (Waring, 2003)
Rider uses of whip or kicking	The rider applies the whip and or heels with some force in an attempt to make the horse move forward

a five-point scale from 0 (no reaction) to 4 (flight); however, to account for the considerable differences in their potential to cause accidents, the points for the two strongest categories (‘‘sidesteps’’ and ‘‘flight’’) were doubled (Table 2). These observations were taken by an observer standing directly behind the fear stimulus. For a maximum of 3 min (starting when the horse passed the visual barrier and first saw the fear stimulus) or until the horse touched the fear stimulus with the nose or hoof, latency to approach the object within 5, 4, 3, 2, 1, 0.5 and 0 (touch) m were recorded during the test as indicators of fear. Video recordings from a camera positioned to the side of the fear test stimulus were used to take these time measurements (Fig. 3).

2.7. Statistical analysis

All analyses were conducted in SAS 9.1 (SAS Institute, Inc. Campus Drive, Cary, NC 27513, USA, http://www.sas.com/).

2.7.1. Conditioning phase

Average heart rate, as well as time (s) taken per conditioning round (as a measure of walking/trotting speed) were analysed using a mixed model with repeated measures over rounds 1–30. Horse was considered a random factor, and treatment, discipline, gait (walk/trot), behavioural observations and time taken to complete the round were considered fixed factors. The model was reduced if a term was not significant ($P > 0.1$). Horse information including age, gender, and breed and other information, such as maze-arm colour and treatment side was likewise tested, but were not included in the model as they were not significant ($P > 0.1$). Thus, the final model for heart rate was:

$$y_{ijklmno} = \text{animal}_i + \text{treatment}_j + \text{gait}_k + \text{time}_l + \text{backing up}_m + \text{stumbling}_n + \text{error}_{ijklmno}.$$

Behavioural data were analysed separately for each of the 14 categories listed in Table 1. In addition, the overall sum of counts for all 14 behaviour categories combined was analysed. The analyses were conducted in a similar manner as described above with heart rates, however, using a generalised linear mixed model assuming an underlying Poisson (for tail-swishing and overall sum of behavioural counts) or Binomial (for all individual behaviour categories except tail-swishing) distribution to fit the data. In the latter case, data were converted to binary data by distinguishing only between occurrence (regardless of frequency) and non-occurrence of the type of behaviour.

2.7.2. Preference test

Sequential analysis (Bross, 1952) was used to determine significance of a horse's preferences for maze-arms (i.e. N or R). Sequential analysis allows immediate statistical evaluation of two-choice data during collection by plotting outcomes of each individual choice on a graph indicating significance at a set level ($P < 0.05$ was chosen for the present study). Therefore, data collection could be minimised, as testing could be terminated as soon as significance was reached. A two-tailed Binomial test and exact Sterne limits (Santner and Duffy, 1989) for confidence intervals (CI) was used to assess the overall significance of horses' choices.

2.7.3. Fear test

Treating recordings exceeding the maximum allowance of 3 min as censored data (i.e. using survival analysis), slopes were calculated for the time taken to approach the fear stimulus within 5, 4, 3, 2, 1, 0.5, and 0 m. These slopes, as well as strength of behavioural reaction, heart rate during the first encounter with the fear stimulus, and heart rate during approach of the fear stimulus, were each analysed as a dependent variable in a mixed model. Heart rates during the ride in R or N immediately before the

Table 2
Description of categories of reaction vigour (adapted from Christensen et al., 2006) used to evaluate strength of horses' reaction during the encounter with the fear stimulus.

Score	Behaviour	Description
8	Flight	The horse jumps to the side and gallops more than four strides away from the stimulus
6	Sidesteps	The horse jumps to the side and trots or gallops away more than two but no more than four strides (Not as energetic as ‘‘flight’’)
2	Alert	The horse quivers and may take up to two steps to the side
1	Head up	The horse throws its head up, stops walking but does not move away
0	None	The horse may or may not direct its attention (turn ear and/or eye) to the stimulus but does not stop walking or lift the head in response to the stimulus

exposure to the novel object were considered as a baseline heart rate and included as a fixed effect ($P < 0.1$). In addition, treatment (R/N), stimulus (U/F), number of the horse's test (first exposure/second exposure), and discipline (D/J) were included as fixed effects if significant at $P < 0.05$. As in the other analyses, horse was included as a random effect.

3. Results

3.1. Conditioning phase

Horses' heart rates (beats per minute ± SE) were not significantly ($F_{1,301} = 0.53$; $P > 0.1$) higher during R (95.06 ± 5.54) than during N (94.03 ± 5.66). However, horses took significantly ($F_{1,301} = 14.92$; $P < 0.0001$) less time to complete rounds ridden in N (40.73 ± 1.27 s) as compared to R (45.20 ± 1.28 s), indicating that horses moved at a slower pace during R. Travelling speed ($F_{1,301} = 18.47$; $P < 0.0001$), as well as gait ($F_{1,301} = 134.16$; $P < 0.0001$), also significantly explained variation in heart rate, such that horses' heart rates were 0.4 ± 0.09 bpm lower per each additional second required to complete the round. When horses stumbled (four times) they had lower ($F_{1,301} = 12.17$; $P = 0.0006$) heart rates than in rounds when they did not stumble (74.44 ± 12.25 versus 94.71± 5.51). Horses that backed up during a treatment round ($n = 11$ times) tended ($F_{1,301} = 2.77$; $P = 0.097$) to have higher heart rates (99.96 ± 7.52) than when they did not back up (89.13 ± 4.73). No other category of recorded behaviour significantly affected heart rates ($P > 0.1$).

Compared to N and accounting for differences in time spent in the treatments (resulting from the differences in travelling speed), in R there were higher ($P < 0.05$) frequencies of all categories of behaviour (change of pace, crabbing, attempted bucks, head-tossing, nose tilting, abnormal oral behaviour, tail-swishing) except for stumbling and snorts (Table 3). Bouts of backing up, groaning and visibility of eye-white were not observed during regular poll flexion, and therefore, statistical comparisons were not possible. In addition, the riders used the whip and their legs more often ($P = 0.0008$) in a forceful way to ride the horse forward during R than N. Details of frequencies and test statistics are given in Table 3.

3.2. Preference test

Fourteen horses, including the three that had an inherent side-preference for the side associated with R, chose regular poll flexion significantly ($P < 0.05$) more often than Rollkur. One horse tended ($P < 0.1$) to prefer Rollkur to regular poll flexion. Due to our preset exclusion criteria of 35 choices, the maximum testing number had been reached at this point, and testing had to be terminated for this horse. On average, horses required 10.3 ± 7.4 trials to reach significance. Casual observations suggested that horses varied in their degrees of decidedness and/or dependence on the rider's cues: some horses appeared to hesitate before making a choice and one horse several times almost walked into the middle wall where left and right arm met, whereas other horses chose a particular side without any apparent hesitation. Overall, horses preferred regular poll flexion significantly more often than expected by chance (Binomial test: $P < 0.001$). The overall probability of horses choosing regular poll flexion more often than chance was 93% (CI: 69.8–99.7%).

3.3. Fear test

During the 10 circles of trot prior to the exposure to the fear stimulus, horses' heart rates were not significantly different between R and N ($F_{1,5} = 0.06$; $P = 0.813$; 96.57 ± 3.78 versus 97.37 ± 3.65), D and J ($F_{1,5} = 1.38$; $P = 0.293$; 100.91 ± 4.68 versus 93.02 ± 4.81), or a horse's 1st or 2nd exposure to the stimulus ($F_{1,5} = 0.22$; $P = 0.66$; 96.22 ± 3.78 versus 97.71 ± 3.65). However, during the encounter with the fear stimulus, horses' heart rates were higher ($F_{1,3} = 13.8$; $P = 0.0339$) in the first test (99.04 ± 4.51) compared to the second test with a different novel object (75.23 ± 4.51), regardless of the nature of the novel object (U or F), indicating that habituation to the situation took place. As hypothesised, horses tended to have higher heart rates ($F_{1,3} = 2.45$; $P = 0.0924$) and to react stronger ($F_{1,7} = 3.8$; = 0.0923) during the encounter with the fear stimulus when ridden in R (94.96 ± 4.51 bpm; 3.0 ± 0.93 reaction points) than when ridden in N (79.31 ± 4.51 bpm; 1.62 ± 0.93 reaction points). Likewise,

Table 3
Mean frequencies ± SE of occurrence of different categories of behaviour per conditioning round (riding on a circle with 20 m diameter) by treatment (N = normal poll flexion, R = Rollkür), and significance of difference.

Behaviour category	N: mean ± SE	R: mean ± SE	*F*-statistics	*P*-value
Tail-swishing	0.513 ± 0.079	2.188 ± 0.213	75.19	<0.0001
Backing up	0.000	0.057 ± 0.016	–	–
Change in pace	0.043 ± 0.018	0.293 ± 0.088	6.05	0.0143
Attempted bucks	0.004 ± 0.004	0.039 ± 0.013	16.25	<0.0001
Crabbing	0.017 ± 0.014	0.253 ± 0.038	31.36	<0.0001
Abnormal oral beh.	0.100 ± 0.023	0.341 ± 0.049	18.33	<0.0001
Ears fixed back	0.039 ± 0.013	0.170 ± 0.025	29.78	<0.0001
Head-tossing	0.035 ± 0.012	0.135 ± 0.030	12.93	0.0004
Nose tilting	0.009± 0.006	0.035 ± 0.012	5.06	0.0251
Eye-white visible	0.000	0.044 ± 0.014	–	–
Stumbling	0.009 ± 0.006	0.009 ± 0.006	2.14	n.s.
Snorting	0.022 ± 0.010	0.022 ± 0.010	0.12	n.s.
Groaning	0.000	0.000	–	–
Sum horse behaviour	0.791 ± 0.087	3.576 ± 0.239	74.19	<0.0001
Rider: whip/legs	0.022 ± 0.010	0.083 ± 0.027	11.33	0.0008

heart rates tended ($F_{1,4}$ = 5.69; P = 0.0755) to be higher during the approach when horses were ridden in R (83.03 ± 5.22) compared to N (74.10 ± 5.22), regardless of the type of stimulus or the horse's discipline. However, in keeping with the previous findings for the first encounter of the stimulus, when tested for the first time (87.85 ± 5.22) horse's heart rates were higher ($F_{1,4}$ = 24.63; P = 0.0077) during these 3 min of approaching the fear stimulus compared to the second time (69.28 ± 5.22).

Differences in strength of behavioural reactions during the first encounter with the fear stimulus were not statistically significant between order ($F_{1,7}$ = 0.02; P = 0.890; 1st: 2.25 ± 0.97 versus 2nd: 2.37 ± 0.97), type of stimulus ($F_{1,7}$ = 0.55; P = 0.483; F: 2.62 ± 0.96 versus U: 2.00 ± 0.96), or discipline ($F_{1,7}$ = 1.21; P = 0.308; D: 3.25 ± 1.21 versus J: 1.37 ± 1.21).

Time taken to approach the fear stimulus within 4 m tended ($F_{1,7}$ = 3.97; P = 0.0865) to be longer when ridden in R (37.8 s ± 7.8) than when ridden in N (16.3 s ± 7.8), and D ($F_{1,7}$ = 3.71; P = 0.0956; 37.9 s ± 8.0) tended to take longer than J (16.1 s ± 8.0) regardless of the test order or type of stimulus ($P < 0.1$). Similar patterns were observed for time taken to approach the fear stimulus within 3, 2, 1, and 0.5 m. Whether or not horses had touched the fear stimulus by the end of the 3 min depended on the type of stimulus ($F_{1,7}$ = 7.0; P = 0.0331; U: n = 6 versus F: n = 2) but not on the horse's discipline ($F_{1,7}$ = 0.86; P = 0.382; D: n = 5 versus J: n = 3), treatment ($F_{1,7}$ = 0.00; P = 1.00; R: n = 4 versus N: n = 4) or test order ($F_{1,7}$ = 0.00; P = 1.00; 1st: n = 4 versus 2nd: n = 4).

4. Discussion

The present study provides evidence that horses avoid Rollkur in favour of regular poll flexion. Horses were also more likely to show behaviour patterns suggestive of stress, discomfort, conflict or frustration when ridden in a coercively obtained Rollkur than when ridden with normal poll flexion. The presence of discomfort or frustration is supported by heart rates that were indicative of higher emotional arousal during R. Also, the slightly stronger reactions and greater reluctance to approach fear stimuli following bouts of R also points towards higher, negative arousal during R (cp. Brown et al., 1951). In combination, these results suggest that this coercive riding style may not only compromise the horse's welfare but can also put horse and rider at a greater risk of injuries resulting from the horse's fear reaction.

4.1. Conditioning phase

Heart rates during walk and trot in the conditioning phase were in agreement with values reported in the literature (e.g. Clayton, 1991). There was no significant difference in heart rates between riding styles. This, in combination with the lower speed during Rollkur and so possibly lower physical exertion may lead one to speculate that horses were experiencing higher arousal during R compared to regular poll flexion. Since heart rate responses to different challenges are additive (Myrtek, 2004), the two factors of reduced physical effort but higher emotional arousal during R probably led to equally high heart rates. Conversely, one may also speculate that similarly high heart rates during R, in spite of slower movements, may be the result of high physical effort required during the unusual strain on muscles during R (as suggested, e.g. by Sloet van Oldruitenborgh-Oosterbaan et al., 2006) that counteracts the lower physical effort required for slower movements.

It is important to identify behavioural signs in the horse indicative of discomfort, so that judges can be provided with better reference guidelines when evaluating the "happiness" of a horse. Even when accounting for different amounts of time spent riding in the two treatments, with the exception of stumbling and snorting, all types of behaviour (change in pace, bucking, crabbing, mouth opening, ear fixation, head-tossing, head-tilting, tail-swishing) were shown significantly less often or not at all (backing, groaning and visibility of eye-white) during regular poll flexion as compared to R. These higher frequencies during the non-preferred and presumably more stressful riding style indicate that these behavioural measurements may be valid indicators of discomfort in the horse that could be used, e.g. by judges.

4.2. Preference test

Riders used greater effort to ride the horses forward during R than in regular poll flexion, indicating that horses were more reluctant to move forward during R. Likely, horses' reluctance was due to their restricted vision (McGreevy, 2004) and because they may have understood the rein pressure as a stop signal (McGreevy et al., 2005). There is also evidence that horses do not value exercise, especially if forced, very highly. For instance, Houpt (2007) showed that horses worked much less in an operant task to obtain a short turnout into a paddock as compared to obtaining a food reward, and in a preference test most horses (exact numbers were not given) preferred to return to the stall rather than receiving exercise on a treadmill. Even though there are other factors associated with riding, such as social contact with the rider or the horse's level of fitness that might influence the value a horse places on being ridden, it is likely that the exercise aspect of riding will, in combination with possible discomfort due to the rider's actions (such as, e.g. the use of whip and spurs as tools for strong negative reinforcement or punishment), override any other potentially positive factors. Together with our findings of higher levels of stress during R, it therefore seems likely in the choice situation that horses avoided Rollkur rather than preferring regular poll flexion.

Overall, horses clearly distinguished between Rollkur and regular poll flexion, and inherent side preferences were overridden by preferences for riding treatments. As none of the horses in the present study had previous experience with Rollkur, it is possible that horses simply chose what was familiar to them. Unlike the results from the study of Sloet van Oldruitenborgh-Oosterbaan et al. (2006) where horses were ridden in the less constrained low, deep and round posture, it was apparent from the behavioural reactions that horses in the present study were not used to being ridden Rollkur. Even though only eleven horses achieved a position as extreme as theoretically possible, all seemed uneasy and were reluctant or resistant to move forward when ridden in Rollkur. The ideal experimental design would have been to have half the horses accustomed to riding in Rollkur and half accustomed to riding normal poll flexion. However, this was not possible, and as a compromise, dressage and show-jumping horses that were accustomed to different degrees of poll flexion were chosen for the present study. The similar reaction of these horses regardless of their being accustomed to poll flexion or not may point towards the hypothesis that familiarity with Rollkur may not be a factor in the horses' avoidance of it. However, long-term studies with horses accustomed to Rollkur are needed to substantiate this suggestion.

Another drawback of the present study is that riders were not blind to the treatments. It is possible that the riders in the present study gave unconscious (or possibly even conscious) cues to the horses as to which maze-arm to choose. Hence, an improvement would have been to use an additional rider for the preference test: a new rider blind to the treatments riding only the choice part in the maze, the other riding only the rounds in the corresponding treatment the horses had chosen. However, a pilot study (Keil, 2008) revealed that the frequent remounting appeared to stress and/or confuse the horses resulting eventually, for example, in refusal to enter the maze. Therefore, using treatment-blind riders was not an option in the present study. However, the fact that some horses did not exclusively choose the maze-arm associated with regular poll flexion, plus the fact that one horse several times almost walked into the middle wall where left and right arm met, indicates that the riders' influence, if present, may not have been a major variable.

4.3. Fear test

Novel object tests have been employed in horses, for instance, by Wolff et al. (1997), and appear a valid and reliable method to assess horses' fear reactivity. The stronger reaction to the fear stimuli while in Rollkur compared to normal poll flexion indicates that R causes a state of heightened arousal or anxiety, which has been shown to result in stronger fear reactions during the encounter of fear stimuli (e.g. Brown et al., 1951). Therefore, riding horses in Rollkur may have implications for horse and rider safety because the risk of an accident due to the horse's fear reaction is increased. Overall, strength of behavioural reactions was lower in the present study compared to similarly designed studies (e.g. Christensen et al., 2005). However, all previous studies tested horses without a rider mounted, suggesting that the riders influenced the horses' reaction. Stronger reactions in dressage compared to show-jumping horses were expected because they have been previously found by Hausberger et al. (2004) and von Borstel (2007), and although this was not supported by the reaction vigour, they were shown in differences in latency to approach.

4.4. General discussion

Based on subjective observations, some authors suggest that Rollkur (or the use of draw-reins) have positive effects on the horse's responsiveness to the rider and its movement (Sloet van Oldruitenborgh-Oosterbaan et al., 2006; van Weeren et al., 2006). The increased responsiveness of the horse is most likely the effect of the restricted vision in the Rollkur posture (McGreevy, 2004), which makes the horse dependent on the rider's cues to navigate. However, this increased responsiveness was not observed with the horses in the present study, which instead often attempted to evade the posture, e.g. by head-tossing. In addition to increased responsiveness, some authors (e.g. van Weeren et al., 2006) report a perceived decrease in stride length and an increase in range of motion during Rollkur. This is, however, not supported by Rhodin et al. (2005) who found that different head positions did not affect stride length or back kinematics during trot. Although these extravagant movements are sometimes falsely rewarded by judges in dressage (cp. Ödberg and Bouissou, 1999), others argue that these forceful training practices can be detrimental to the horse's health (Heuschmann, 2007) and affect "wastage", and that more emphasis should be placed again on the lightness of the rider–horse communication (in particular by training judges) and harmony between the dyad (Ödberg and Bouissou, 1999). In addition, there is no evidence that this effect of changes in motion and responsiveness, if it exists, continues to last after the horse is released into a more normal posture required in the competition ring. The usefulness of riding horses in the Rollkur posture can therefore be questioned.

5. Conclusions

The present study demonstrates that horses show higher levels of discomfort when ridden in a coercively obtained Rollkur posture compared to regular poll flexion, and that they will avoid being ridden in Rollkur if given the chance. Given the potential negative impact on rider safety and welfare of the horse as demonstrated in the present study, and for want of clear scientific evidence of any beneficial effects, it is suggested that Rollkur should not be practiced in a coercive manner.

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