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Work it out: Investigating the effect of workload on discomfort and stress physiology of riding school horses

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ABSTRACT

Riding schools play an essential role in the equestrian industry and in education. These establishments are reliant on horses to work for numerous hours, often with riders of different abilities. However, little is known about the impact workload has on the well-being of these horses and effective monitoring of welfare is required for animal-based industries to maintain their Social Licence to Operate. The aim of the current study was to investigate how the quantity of work carried out by riding school horses affects their behaviour and physiology, providing evidence as a starting point to identify suitable levels of work that riding school horses can be used for before their welfare is compromised. Horses (n = 30) were observed 1–2 h after completing their workload on a day of Rest, Moderate (1–2 h) and Hard work (3–4 h). Infrared thermography of eye temperature (IRT) and heart rate variability (RMSSD) were measured as indicators of arousal. The Horse Grimace Scale (HGS) was scored treatment-blind to measure discomfort and pain. No significant difference was found between RMSSD or eye temperature depending on the level of workload, indicating subjects were able to cope with increasing demands. However, there was a significant difference in the HGS score between Rest, Moderate and Hard work ($p < 0.001$). This indicates a greater degree of discomfort following an increase in hours of work. Another possible explanation for the increase of the HGS score is that tiredness can influence the presence of some of the FAUs (e.g., backward ears and orbital tightening) making it more difficult to discriminate between whether a horse was in pain or the increased score is a consequence of being physically tired after the work. Findings indicate that 1–2 days of working 3–4 h can be appropriate in horses conditioned to the work in well managed riding facilities, however further research is needed to determine how long increased HGS lasts to determine how often days of hard work may occur without impacting welfare.

1. Introduction

There are an estimated 58.7 million horses in the world, with approximately 6.3 million of those residing in Europe (FAOSTAT, 2017). An estimated 1.8 million regular horse riders are active within the United Kingdom alone, with 374,000 households owning at least one horse (Anon, 2019). Riding schools are of critical importance to this equestrian industry, since in many countries this process of riding and owning horses typically begins with foundation riding school education. Concern has emerged in recent years that the welfare of horses may not be optimal (Furtado et al., 2021; Horseman et al., 2016). In fact, criticisms of the use of horses for human pursuits threatens the industry's Social Licence to Operate (Duncan et al., 2018). Riding schools must consider the welfare of their horses and the commercial viability of their business such that each horse completes enough work to "earn their keep" without negatively affecting their welfare. Without evidence based decision-making to balance benefits to people, commercial pressures and the well-being of the animals themselves, industries such as

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riding schools could face an uncertain future. Yet, if riding schools are not maintained, people will assume ownership of horses without this critical early education in the fundamentals of riding, which raises serious safety and welfare concerns. Therefore, research into the impact of workload in these horses is timely.

Welfare assessment and research often focusses on husbandry practices as psychological stressors (Luke et al., 2022; McBride and Mills, 2012). However, when looking at ridden horses, stress can also be affected by time outside of housing such as exposure to novel stimuli and environments, separation from conspecifics and exposure to unfamiliar horses (Borstel et al., 2017; Luke et al., 2022). Unlike competition or racing horses, riding school horses do not often face novelty or separation but they are not ridden by a competent individual rider. Instead, they work with a variety of riders, most of whom are novices who are still learning how to sit properly (Masko et al., 2019) while developing their balance with little control over rein contact or leg aids (Hall et al., 2008). This, coupled with varying rider weights and sizes, makes the riding school horse's job uniquely challenging and so their welfare during ridden work must be carefully monitored.

Many riding schools have horses that are considered "lazy" and hard to "get going," which often appear apathetic and lethargic (Hall et al., 2008; McGreevy and McLean, 2005). Some may regard this as desirable as these horses are believed to be safe, but it is likely that this unresponsive behaviour masks physiological indicators of stress (Squibb et al., 2018). They may have been subjected to repeated aversive stimuli at the hands of unbalanced riders with insufficient control over rein contact and leg aids (Lesimple et al., 2010; McGreevy and McLean, 2005). As a result of the inevitability of these negative situations, anxiety and stress have been replaced with emotional depression, referred to as learned helplessness (Hall et al., 2008). Learned helplessness is a psychological condition in which individuals come to believe they have no control over unpleasant or damaging situations, that their actions are ineffective and that they are helpless (Hall et al., 2008). When training and management practises are continually unpleasant for the horse and there is no clear relationship between behaviour and outcome, this is likely to impair learning and performance, as well as compromise welfare (McLean and Christensen, 2017).

There is a growing body of evidence showing an association between both physical and emotional stress and workload (Lesimple et al., 2010). However, different riding methods may impose a variety of physical and psychological pressures on a horse (Goodwin et al., 2009; Hausberger et al., 2009; McLean and McGreevy, 2010). Knowing how work impacts the emotional responses of ridden horses is essential for safeguarding their welfare. Nevertheless, only limited ridden environments have been evaluated to date, and the effects of workload on riding school horses are still poorly understood. To protect the welfare of riding school horses, which may work long hours with riders of varying skill levels, it is essential to instigate research into the effects of workload on these horses. The aim of the current study was to determine how the quantity of work carried out by riding school horses affects the horse's behaviour and physiology to provide evidence that may contribute towards identifying appropriate levels of work that riding school horses can be used for before their welfare is compromised. To this end, thirty horses were observed on Rest, Moderate and Hard work days and their Horse Grimace Scale (HGS) score, Heart Rate Variability (HRV) and Infrared Thermography (IRT) recorded at the end of each day for comparison.

2. Materials and methods

2.1. Ethics

Consent was obtained from the horses' owner prior to data collection via the completion of a participant information form. All data given was held in compliance with the Data Protection Act (2018). The horse's owner was permitted to withdraw a subject at any time and for any reason prior to the point of data processing. Prior to commencement, the Nottingham Trent University School of Animal, Rural and Environmental Sciences Ethical Review Committee granted ethical approval for this study (Approval code: ARE212241). No management or working routines were affected by the study which used opportunistic methods in working riding school horses.

2.2. Subjects

A sample of 30 horses (19 geldings and 11 mares) were sourced from an independent riding school. The sample included all available horses at the facility that were expected to work at least one day of each treatment during the observation period (see below). Subjects ages ranged between 8 and 28 years (mean=17.6 ± 6.4 years) and were of a variety of breeds. All horses were experienced riding school horses working approximately one to four hours per day five days a week, with a rest day twice a week. The horses used were turned out at night, in a mixed herd, coming into the stables during the day, with free access to water and adlib haylage while stabled between lessons. All horses were in good condition with no obvious signs of injuries, sickness, or disease and were deemed fit to work by the yard manager. No manipulations were made to the horses' care, routine, or workload during data collection.

2.3. Testing conditions

Data was collected over a six-week period (May to July 2022) with between two and ten horses tested per day depending on their availability. Each horse acted as their own control participating in each treatment. The horses underwent three testing conditions: a day of rest (Rest), a day of moderate work (1–2 h per day; Moderate) and a day of hard work (3–4 h per day; Hard). Treatment could not be completely randomised as workload followed a weekly pattern with horses rested on Friday and Monday, worked moderately throughout the week (with some horses occasionally working hard) and then worked hard on Saturdays. The order of treatment each subject was observed was randomised but will unavoidably be affected by workloads on prior days which follow a set pattern. Subjects included in the sample were conditioned to this workload routine in that they were not newly acquired and had not recently been out of work, however more detailed records for each animal are not available.

When testing on days of work the horses were allowed an hour within their stable for their body temperatures to return to normal following the completion of their last lesson. This was so that the horse's body temperature could recover from the exercise that was just completed to reduce the likelihood that greater workload would raise temperature through exertion, as opposed to stress (Lindinger and Waller, 2022). Testing was then carried out within a two-hour period as temperature fluctuate diurnally (Piccione et al., 2008). Full details are presented below but the overall protocol was as follows: IRT was measured first; the heart rate monitor was then fitted and, after an acclimatisation period, the heart rate recording was started and the video recording for HGS taken at the same time.

To be included in the study, subjects must have worked at walk, trot and canter in the ridden sessions. Some of the riding sessions may have included some show jumping up to a height of 70 cm, which is not energetically more costly than canter work (Léguillette et al., 2020). Only riding sessions where the horses were worked in the arena were included in this study, with sessions that included hacking and cross-country riding excluded from the study. To minimise the influence of environmental novelty, testing was conducted in the subject's home environment (either within or just outside a stable they were familiar with but always within their enclosed barn) with companions in nearby stables (Wolff et al., 1997).

2.4. Eye temperature

A FLIR E76 thermal imaging camera (FLIR Systems, Oregon, United States) was used to collect thermographic images of each horse's left eye. All thermal images were attained at an angle of 90° from the left sagittal plane of the horse, from a distance of one metre (Ijichi et al., 2020). This camera has a thermal sensitivity of < 0.02 °C and can detect temperature over a range of − 20–250 °C. Ambient temperature and relative humidity were recorded at 30-minute intervals inside the stable barn and these values were entered into the camera's setting to allow for atmospheric changes during the sampling period, as previously recommended by (Stewart, 2007). Images were taken in the stable to reduce the effects of direct sunlight (Church et al., 2014).

After collecting the thermal images, they were uploaded to the thermal analysis software FLIR Thermal Studio (FLIR Systems, Oregon, United States). Analysis of thermal imaging was undertaken using the ellipse function to determine the maximum temperature inside an oval region drawn around the inner canthus of the eye, including the lacrimal caruncle 1 cm outside the eyelid.

2.5. Heart Rate Variability (HRV)

Horses were fitted with a heart rate monitor (Polar Equine V800 Science, Polar Electro Oy, Kempele, Finland) to enable continuous recording HRV, measured as inter-beat intervals. This device has been validated for measuring HRV in stationary horses (Mott et al., 2021). The heart rate sensor strap was fitted firmly around the horse's thorax with the HR sensor positioned on the left-hand side halfway between the withers and the sternum. Ultrasound transmission gel (Anagel Ultrasound Gel) was generously placed on the heart rate sensor strap to maximise the electrical contact with the tissue and the accuracy of the results. All horses included in the study routinely wear equipment that fits in a comparable manner around the thorax, where the recording equipment was placed. Once fitted, the horses were given a five-minute acclimatisation period followed by a three-minute recording period. This three-minute recording is ideal for RMSSD recording since it allows for precise recording of high frequency beat-to-beat changes (Stucke et al., 2015), that represent vagal regulatory activities (von Borell et al., 2007).

Heart rate analysis was performed using Kubios HRV software (ver. 3.5.0, Biomedical Signal Analysis and Medical Imaging Group, Department of Applied Physics, University of Eastern Finland, Kuopio, Finland.). Artefact correction was set at a custom level of 0.3 (Ille et al., 2014), eliminating RR values that varied by more than 30% from the prior interval. This signifies that if a single RR (the time elapsed between two successive R-waves) interval differs by more than 30% from the preceding interval, it is termed an erroneous reading. For data analysis, the root mean square of successive differences (RMSSD) between adjacent normal RR intervals, was utilised, due to being more reliable than the standard deviation of the RR intervals (SDNN) for recordings with short duration.

2.6. Facial expression assessment

A one-minute video of the facial expression of the horse was recorded using a JVC GC-PX10 camera; the videos were taken with a camera held by the researcher, to enable the face of the horse to remain in view of the camera for the duration of the recording. The videos were taken with horses in the stable, in the same place, the side was the most convenient for not disturbing the horse. An example of images is reported in Fig. 1. The facial expression was evaluated using the Horse Grimace Scale (HGS), a pain classification system (Dalla Costa et al., 2014). The six facial action units (FAU) were used for scoring each horse in each testing condition. The facial action units encompass six facial features: stiffly backward ears; orbital tightening; tension above the eye area, prominent strained chewing muscles; mouth strained; and pronounced chin and nostril strain, for a detailed description of each facial action unit see Table 1. Two trained and treatment-blind observers (equine practitioners specializing in applied ethology and animal welfare) scored all the videos using the HGS. When the observer was confident that, for most of the time, the action unit was not present, a score of 0 was awarded; a score of 1 indicated a high degree of confidence that the action unit was moderately present, while a score of 2 indicated a high degree of certainty that the action unit was present. Where a region of the facial action unit was not clearly visible "not applicable" was awarded. The six action unit scores were summed and a mean of the

Table 1
Description of each Facial Action Unit (FAU) of the Horse Grimace Scale (HGS). The table has been adapted from Dalla Costa et al. (2016).

Facial Action Unit (FAU)	Description
Stiffly backwards ear	The ears are held stiffly and turned backwards; movements are limited also in presence of environmental stimuli
Orbital tightening	The eyelid is half-closed or closed, the orbit is contracted, eyes are not focused on the environment
Tension above the eye area	Increased muscle tension in the area above the eyes, the underlying bone structure becomes clearly visible
Prominent strained chewing muscles	Increased tension of the chewing muscles, which becomes prominent and clearly recognisable
Mouth strained and pronounced chin	Strained mouth, the corner of the lips is shortened, the lower lip is tense, the chin is contract and becomes more pronounced
Strained nostrils and flattening of the profile	The nostrils are dilated and strained, the profile changes and two bulges are visible one at the nostrils and upper lip

Fig. 1. Shows the same individual from the sample on the evenings of a) Rest; b) Moderate; and c) Hard work days, demonstrating typical changes to Facial Action Units.

scores from the two assessors was calculated, accounting for missed FAUs. The score for each facial action unit from all videos was totalled to give the HGS score for each subject in each testing condition.

2.7. Statistical analysis

All statistical analyses were conducted using SPSS version 28.0.1.1 (15). Data were tested for normality and homogeneity of variance using Kolmogorov-Smirnov and Levene's tests, respectively; HGS was not normally distributed, therefore data were log10 transformed to meet assumptions of normality of this variable. A repeated measure ANOVA was used to investigate any workload effect on RMSSD, eye temperature and HGS score. Assumptions of sphericity were met. Five horses did not happen to complete Hard work days during the observation due to only being suitable for a limited cohort of riders, therefore they were excluded from the analysis. These subjects still provided descriptive data for Rest and Moderate workdays. Bonferroni post-hoc tests were used to account for repeated comparisons.

3. Results

3.1. Heart rate and heart rate variability

Mauchley's test indicated that the assumptions of sphericity had not been violated ($\chi 2$ (2) = 5.70, p = 0.06). There was no significant difference in the RMSSD depending on the workload (F_2, 48 = 1.39, p = 0.26). RMSSD was 82.44 ± 37.96 for Rest, 75.84 ± 25.97 for Moderate, and 76.56 ± 32.56 for Hard work conditions.

3.2. Eye temperature

Mauchley's test indicated that the assumptions of sphericity had not been violated (χ 2 (2) = 0.03, p = 0.98). There was no significant difference in eye temperature depending on the level of workload ($F_{2.26}$ = 2.55, p = 0.089). Bonferroni post-hoc test was used to assess the slight tendency. This confirmed there was no significant difference between Rest and Moderate work ($t_{29} = -1.19$, p = 0.24), Moderate and Hard work ($t_{24} = -0.34$, p = 0.74), and Rest and Hard work ($t_{24} = -1.74$, p = 0.10) eye temperatures. Eye temperature was 36.41 °C ± 0.81 at Rest, 36.64 °C ± 0.71 for Moderate and 36.68 °C ± 0.77 for Hard work conditions.

3.3. Facial expression assessment

Mauchley's test indicated that the assumptions of sphericity had not been violated (χ 2 (2) = 4.46, p = 0.11). There was a significant difference in HGS depending on the workload (F=15.629, p < 0.001). Bonferroni post hoc tests confirmed that there were significant differences in the HGS score between workload conditions (Fig. 2). There was a significant difference between Rest and Moderate work (p = 0.002), and Rest and Hard work (P < 0.001) conditions. The mean HGS score for horses at Rest was 3.30 ± 1.28, increasing to 4.22 ± 1.34 in Moderate and 4.88 ± 1.47 in Hard workload conditions (Fig. 1).

4. Discussion

It is of fundamental importance to accurately identify stress and discomfort in riding school horses, as these conditions can exacerbate emotional arousal, resulting in detrimental effects on the horse's welfare. The equine industry only retains its Social Licence to Operate if the use of horses is perceived to be humane and appropriate (Duncan et al., 2018) and evidence is needed to make informed decisions. Riding school horses engage with a wide range of riders, from novice to experienced, multiple times a day. The effect of workload on these horses has been overlooked in research yet establishments must make decisions which balance their commercial pressures with the well-being of their animals. Therefore, the aim of this study was to investigate how the level of workload affects the behaviour and physiology of riding school horses. Consequently, HGS as an indicator of pain and discomfort, and HRV and IRT measures of arousal, were taken after three different work conditions: Rest, Moderate (one to two hours) and Hard work (three to four hours).

There was no statistically significant difference in RMSSD between the three workloads, indicating that the increased workload had not compromised welfare. Though it is possible that the horses found the work challenging at the time, if so, they had returned to levels comparable with Rest days within one to two hours of completing their working day. The RMSSD values obtained in this study are within a normal healthy range. Horses in stressful settings have lower RMSSD values, indicating decreased parasympathetic activity (Visser et al., 2002). Schmidt et al. (2010) found that when young horses were mounted for the first time by a rider, they experienced a stress response with low RMSSD values that were independent of physical activity.

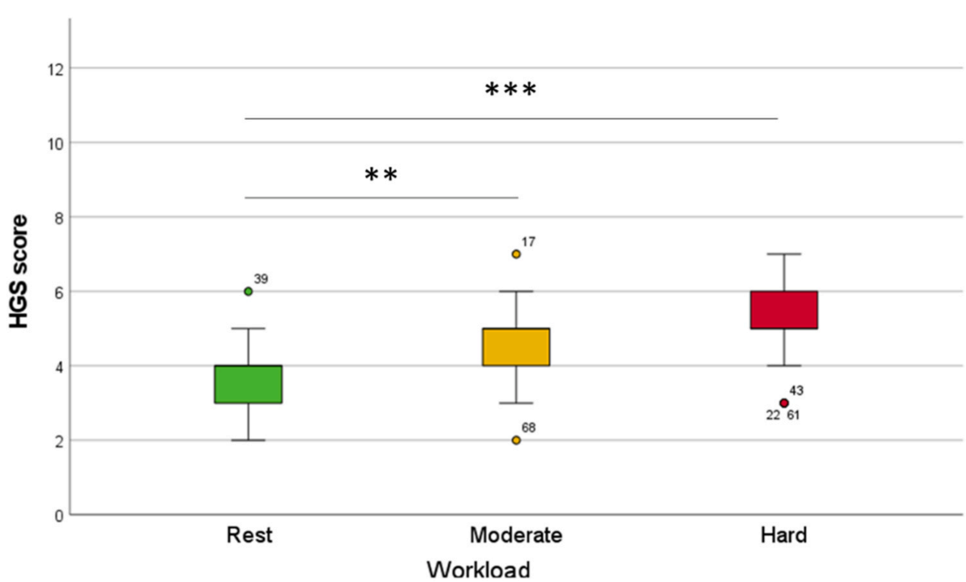

Fig. 2. Horse Grimace Scale (HGS) total scores for horses (n = 25) over three workloads conditions (**p < 0.01; ***p < 0.001). Outliers (1.5–3 times length of the box), labelled with the individual case numbers, are graphed as circles.

Furthermore, significant reductions in RMSSD occur on the second and third days after competition in dressage and show jumping horses, when the competition demands were raised daily (Becker-Birck et al., 2013). This demonstrates that RMSSD after exercise does respond to changing levels of demand and supports the interpretation that, if any increase in stress occurred during riding (which we did not measure here), horses quickly returned to resting levels. Therefore, even if the additional riding sessions caused stress, it appears to be within the horses' ability to cope with the challenge and is unlikely to be a welfare concern.

Consistent with RMSSD responses, there was also no significant difference in eye temperature with increasing workload, suggesting that the increased workload had not compromised welfare. Monitoring changes in eye temperature has been successfully used to analyse horses' responses to potentially stressful events in a variety of ridden situations such as use of tight crank nosebands (Fenner et al., 2016; McGreevy et al., 2012), in response to exertion (Bartolomé et al., 2013; Esteves Trindade et al., 2019; Hall et al., 2011; Sánchez et al., 2016; Soroko et al., 2016; Valera et al., 2012) and to stress per se (Dai et al., 2015; Hall et al., 2014; Ijichi et al., 2019, 2018) indicating its value as a measure of response to both physical and mental demands of increased workload. In the current study, no significant differences were found in eye temperatures between workloads which indicates that the Hard workload condition was within the subject's capacity to cope with the demands placed upon them.

Despite the consistency in physiological measures over increasing workloads, there was a statistically significant difference in the horses' grimace scores after Rest, Moderate, and Hard work. This significance indicates that the horses are exhibiting signs of pain or discomfort in response to increased workload. It is worth underlining that the HGS scores, compared with those described in healthy young horses (Dalla Costa et al., 2014) were higher even in the resting condition, 3.30 $\pm$ 1.28 versus 2 $\pm$ 0.50 as reported by Dalla Costa et al., 2014. Most of the observations (83%) obtained a score of less than six indicating that the pain or discomfort experienced by these horses due to the increase in workload was not excessive. It should also be considered that tiredness can influence the presence of some of the FAUs (e.g., backward ears and orbital tightening) (Trindade et al., 2020) making more difficult to discriminate between whether scores were due to pain or a consequence of being physically tired by increased workload. In fact, this is the first time the HGS has been applied to horses' post-exercise, so further research is required to investigate interactions between pain and post-exercise tiredness. Regardless, the increased scores were observed on the evening of the day of work. They are likely to be short-term since all observations of horses after a day of rest occurred within several days of a day of Hard work and raised HGS scores were not seen at this time. However, further research is needed to determine how long it takes a conditioned riding school horse to return to baseline HGS following a day of harder work. This is crucial to understand how often, and when, these sessions may take place before impacting the well-being of the animal. Considering the subjects in this study typically complete one to two hard days of work per week, and neither measure of physiology was influenced by slightly increased HGS following hard work, we can infer that the demands placed on them are within their individual ability to cope.

Taken together, results indicate that increased workload causes an increase in discomfort but not sufficient to affect the individual's attempts to cope. However, there are important caveats to these findings. Data was acquired from an approved riding school that met the standards set by the British Horse Society (British Horse Society, n.d.). All horses at this facility received regular hoof care, turnout, were provided with sufficient nutrition and calories in the form of hard feed and forage and were equipped with individual fitted tack. Rider weight limits of < 90 kg were in place and riders were matched to horses of an appropriate size within this limit, to ensure the well-being of the horses was protected. Further, reputable establishments make efforts to match rider ability with the experience and temperament of the horse. Research on horses used for therapeutic riding revealed disparities in stress levels between rider groups, despite the fact that session workload stress was equal (Cravana et al., 2021). Thus, the findings from this study can only be applied to similarly well-run facilities but a wide range of converging factors must be considered alongside workload when making informed decisions about the use of working horses (Ladewig et al., 2022; Mcgreevy et al., 2011).

5. Conclusions

The current study explored the relationship between the quantity of work carried out by riding school horses and its effect on behaviour and physiology. Physiological indicators of stress did not indicate that the horses were affected by an increase in workload, but the behavioural indicators using the horse grimace scale did indicate that they were exhibiting signs of discomfort at Rest, which increased following the increase in workload. However, the physiological indicators of arousal suggest that the discomfort experienced by these horses due to the increase in workload is not seriously beyond the individual's ability to cope. It is possible that horses had a stress response during the ridden sessions, which was not measured here. However, even if this was the case, stress physiology had return to resting levels within 1–2 h on completing work which would not necessarily constitute compromised welfare as very acute, periodic stress is not considered concerning (unless extreme). Therefore, it can be concluded that workload of up to three to four hours for one to two days each week is at an acceptable level of challenge in well maintained horses conditioned to the work. However, individuals should be closely monitored following a day of hard work to ensure that they have sufficiently recovered before continuing to work. Training managers of riding facilities to score the Horse Grimace Scale would improve evidence-based decision making.

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CRediT authorship contribution statement

Ijichi, C.: Conceptualisation, Methodology, Resources, Writing – review & editing, Supervision, Project administration. **Wilkinson, A.:** Investigation, Formal analysis, Writing – original draft. **Riva, M.G.:** Formal analysis, Writing – original draft. **Sobrero, L.:** Formal analysis. **Dalla Costa E.:** Writing – original draft, Formal analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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