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A Preliminary Study Exploring the Relationship Between Exercise Regimes and Sleep-Related Behavior in Stabled Horses

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Abstract

Exercise is a recognized time cue for circadian rhythms, influencing sleep architecture and quality across diverse human populations. While its timing and intensity affect sleep outcomes in humans, little is known about how exercise impacts sleep in horses, particularly those with early morning or late evening workloads, as is common in working or competition horses. This study sought to explore this relationship in stabled horses experiencing changes to their workload patterns. Five geldings housed at Hartpury Equestrian Centre were observed across three exercise phases (normal, increased, and return to normal) using an ABA design. Sleep-related behaviors were recorded overnight using closed-circuit television (CCTV) equipment and analyzed using a validated ethogram with continuous focal sampling. Inter-observer reliability tests confirmed consistent behavioral scoring, and data were analyzed using nonparametric statistics to compare behavioral time budgets, as well as postures, across phases. Horses spent the majority of their time awake, followed by sleep and rest, across all exercise phases. Increased exercise led to significantly longer sleep bouts (Phase B: 10.79 min vs. Phase A: 5.33 min, $P < 0.05$) and more frequent rest episodes. Sleep postures also changed, specifically sternal recumbency, where Phases B and C were statistically different from Phase A. Results also indicated a residual effect of exercise on sleep and rest patterns, with sleep patterns remaining altered even after a return to normal exercise (Phase C: 8.98 min), indicating prolonged recovery effects. Findings demonstrate that exercise-induced changes in sleep architecture persist beyond the intervention period, highlighting the importance of recovery planning in equine management and supporting the need for larger-scale studies to disentangle the relationship between sleep and exercise to optimize equine performance and well-being.

Keywords

Equine; rest-activity cycle; welfare; workloads; circadian

1. Introduction

Exercise is recognized as a significant time cue for circadian rhythmicity in humans; however, beyond being an input signal to circadian systems, there is also a strong rhythmic output regulated by the internal clock, which is distinct from other circadian cues such as light [1]. The intricate relationship between exercise and circadian rhythms has been further examined in the context of exercise's impact on human sleep. The magnitude of the effects of locomotor activity on sleep correlates well with the amount of locomotor activity involved [2], and even a single bout of exercise can increase the amount of subsequent slow-wave sleep (SWS) [3]. Studies examining the effects of exercise on sleep demonstrate that sleep architecture can change rapidly, with the magnitude and direction of these effects depending on exercise duration, intensity, and timing [3]. Moreover, as sleep is as much a behaviorally regulated process as a physiological one, neural plasticity enables flexible, state-dependent adjustments in sleep expression, allowing sleep architecture to repeatedly adapt in response to metabolic and environmental demands to support recovery [2,3].

For example, 12 weeks of exercise training increased sleep duration and variables of sleep quality in adolescents [4]. Exercise duration was found to decrease the duration of non–rapid eye movement (NREM) sleep stage (N1, very light sleep) while increasing rapid eye movement (REM) sleep, sleep continuity, and sleep efficiency. Individuals who engage in higher levels or longer durations of physical activity are more likely to experience better sleep quality [5,6], lending support to the hypothesis that overall fitness can be an indicator of sleep quality. However, the interaction between sleep and exercise differs across multiple or diverse populations [6]. In an adult population, when additional leisure time was set aside for physical activity, above and beyond occupational physical activity, sleep quality and duration improved [7]. Meanwhile, physical activity is not necessarily associated with sleep quality for all individuals, particularly in relation to age and sex, which explains why, when compared with middle-aged adults, younger or older adults may see benefits to sleep quality if they change from sedentary to more active lifestyles [8].

The timing of exercise is also important. Exercise shortly before going to bed can produce a stress effect that reduces the amount of subsequent SWS [3]; however, evening exercise can also significantly reduce wakefulness after sleep onset (WASO) [9]. Morning exercise was found to significantly improve the time required to fall asleep (sleep onset latency, SOL). The number of times adult participants woke up during sleep after morning, afternoon, and evening exercise was lowest after bouts of morning physical activity [10]. Exercise earlier in the day appears to improve the quality of nocturnal sleep because exercise stimulates the sympathetic nervous system, which results in enhanced parasympathetic activity [11]. These findings demonstrate that exercise-related changes in sleep architecture are not only of physiological interest but are closely linked to recovery, cognitive function, emotional regulation, and physical performance, highlighting sleep as a critical component of overall health and functional capacity [6,12].

While a wealth of information exists describing the relationship between sleep and exercise in humans, very little exists to quantify this relationship for horses, even though some utility roles involve early morning (e.g., Thoroughbred racehorse training) or late evening exercise (e.g., Fédération Équestre Internationale showjumping competitions) being common practice. As sleep is critical for physiological recovery, cognitive function, and overall welfare, disruptions to rest may impair muscle recovery, learning, and performance. Some studies have examined the effect of sleep on cognitive and physical performance, but findings are contradictory [13–15], and the effect of equine exercise on sleep remains largely unexplored. Early research highlights how, in the period immediately following exercise, horses engage in more drinking and lying behavior but less standing rest behavior [16]. Cumulatively, harness trotting horses were seen to rest more after training days [17]. Nonetheless, these studies did not report 24-h rest patterns or examine specific behaviors related to sleep profiles, leaving key questions about how exercise intensity and timing affect equine sleep architecture, recovery, and overall welfare unanswered. The current study, therefore, aimed to observe the sleep-related behavior of horses experiencing changes in their workloads to determine whether a relationship exists between increasing and decreasing workloads and total duration of rest- and sleep-related behavioral states.

2. Methods

2.1. Subjects

Five riding horses (all geldings) of mixed age, height, and breed, were housed in the same stable for six months prior to the start of the study and were observed in these stables. The sample population was selected based on whether horses were involved in the control and experimental types of exercise and whether they had closed-circuit television (CCTV) equipment set up in their stables. Due to the location of CCTV equipment, horses were located across two barns at Hartpury Equestrian Centre. Three horses were stabled adjacent to one another, with visual contact over the stable door. Each stable measured approximately 3 m × 4 m and was arranged in an American barn with a walkway in the center. The stables were partitioned by breeze block walls, with metal bars at the front and an open-top stable door facing into the central aisle. Two horses were housed in 3.6 m × 3.6 m stables in a separate American barn with a walkway in the center. Stables were partitioned by wooden panels with metal bars at the front and an open-top stable door facing into the central aisle that provided visual contact with other horses in the barn. All horses were bedded on wood shavings (depth: 5–10 cm) covering approximately half of the stable floor area, with rubber matting beneath covering the full floor.

The stables were cleaned each morning between 07:00 and 08:00, when barn lights were turned on, and intermittently throughout the day until roughly 19:00, when barn lights were turned on. Horses had *ad libitum* access to water provided in a large bucket and refreshed regularly throughout the day. Forage was provided in a quantity dictated by the yard managers at 07:00, 12:00, and 19:00, with no other meals provided. The remaining two horses were stabled in the same row, so they also had visual contact with each other but were not next to each other. These stables measured 3.6 m × 3.6 m and were partitioned by wooden panels, with metal bars at the front and an open-top stable door facing into the central aisle, with the same bedding and hay/water regime as the first barn. None of the horses experienced turnout during the days observed for the study.

Normal exercise (Phases A and C) consisted of a maximum of two nonconsecutive hours of ridden work and/or groundwork (light work at walk, trot, and canter) in an arena per day, occurring between 09:00 and 16:00. Increased exercise (Phase B) involved in-hand exercise with greater horse–human interaction time in an arena between 09:30 and 13:30, with breaks, within a three-day program of equine-assisted activity. An example schedule can be found in **Table 1**, highlighting increased time out of the stable.

The additional activity was not a direct result of the study but occurred as part of an external contract, such that ethical approval was granted to observe horses without changing their routine, as required by the study.

Table 1: The schedule of activity horses experienced during Phase B.

Time	Subject	Horse	Location
09:30–10:00	Introduction to the team	Horse ×1	Meeting room and indoor arena
10:00–10:45	Introduction to horses	Horse ×8	Indoor arena
10:45–11:00	Break	N/A	Indoor arena
11:00–12:00	Horsemanship	Horse ×8	Indoor arena
12:00–12:30	Lunch	N/A	Indoor arena
12:30–13:30	Teamwork	Horse ×2	Indoor arena

2.2. Design

This observational study followed an ABA design [18] across three phases. Exercise regimes changed across the observation period according to the following schedule:

Phase A = Normal (control) exercise (horses observed from 02/03 to 05/03/2023)

Phase B = Increased (experimental) exercise (horses observed from 08/03 to 11/03/2023)

Phase C = Normal (control) exercise (horses observed from 15/03 to 19/03/2023)

Horses were observed in their stables from 19:00 to 07:00 retrospectively via recordings obtained from Hikvision CCTV equipment comprising a 16-channel 4K Power over Ethernet network video recorder. Cameras had been pre-installed in individual horse stables. Behaviors were recorded using continuous focal sampling with continuous observation [19] to measure the duration of behavioral states against a predetermined ethogram adapted from [20] and [21] (**Table 2**).

Four different observers completed data extraction. All observers underwent training on the use of the ethogram prior to conducting video analyses. To maintain scoring consistency, inter-observer reliability was assessed using the intraclass correlation coefficient (ICC; two-way mixed model, absolute agreement). The model was chosen to focus on measuring exact agreement rather than ranking consistency [22]. Both single-measure and average-measure ICCS were calculated to estimate reliability for individual raters and the mean ratings across observers. Interpretation of the ICC values followed established guidelines [22], where values above 0.75 indicate good reliability and values above 0.90 reflect excellent reliability. The ICC for single measures showed excellent agreement among observers (ICC = 0.918, 95% CI [0.65–0.998], $F(2,10) = 45.95$, $P < 0.001$). When ratings were averaged across observers, reliability increased further (ICC = 0.985, 95% CI [0.918–1.00], $P < 0.001$). A second reliability test on an independent video subset yielded similar results, confirming strong inter-rater agreement (ICC_{single} = 0.853, 95% CI [0.502–0.996]; ICC_{average} = 0.972, 95% CI [0.858–0.999]; $P < 0.001$). These findings indicate that the ethogram was applied consistently across observers, and subsequent behavioral analyses are unlikely to have been affected by observer bias.

2.3. Data Analysis

All data were tested for normality using the Shapiro–Wilk test and found to be nonparametric. Descriptive statistics were calculated for all behavioral categories, and results were reported as percentages, counts, means with standard deviations, or medians with ranges. Behavioral time budgets were calculated as proportions of total observation time within each phase to account for differences in total duration of footage due to data loss. To investigate variation in behavior and sleep patterns across the three experimental phases (Phase A: normal exercise, Phase B: increased exercise, Phase C: return to baseline), comparisons were conducted using Kruskal–Wallis H tests, followed by post hoc Mann–Whitney U tests with Bonferroni correction to account for multiple comparisons. All analyses were completed using Python 3.11. Data manipulations were performed with the pandas library [23], and statistical testing was conducted with SciPy [24]. Data visualization was produced using matplotlib [25] and seaborn [26] libraries. The significance level was set at $\alpha = 0.05$, with the adjusted α applied for multiple comparisons in post hoc analyses.

2.4. Ethics

Ethical approval was granted by the Hartpury Ethics Committee (ETHICS2022-118). As behavior was recorded over 24 h, interaction between the horses and the human caregivers was visible. Despite not collecting data on these interactions, observers were directed to report any concerning behavior displayed by the horse or observed between horse and caregiver. A poster was mounted outside the stables of the horses involved for the duration of the study to ensure the caregivers were aware that footage was being collected.

3. Results

3.1. Overall Activity Profiles of Horses

A total of 3,653 behavioral observations were made on five horses across three phases: Phase A (normal exercise), Phase B (increased exercise), and Phase C (return to baseline exercise). Throughout all phases, the horses spent most of their time awake (46.92%), followed by sleep (27.45%), resting (19.68%), and engaging in unknown behaviors (5.95%). A Kruskal–Wallis test showed a significant overall difference in how time was distributed among behaviors ($H(3) = 8.89$, $P = 0.031$). However, post hoc analysis revealed that only wakefulness significantly differed from resting between phases ($U = 25$, $P = 0.008$), with no other pairwise differences reaching significance.

Behavioral time allocation varied across the three phases (**Figure 1**). In Phase A, horses spent 55.31% awake, 28.69% sleeping, 14.32% resting, and 1.68% in unknown states. After increased exercise (Phase B), wakefulness dropped to 45.01%, while sleep and resting rose to 33.01% and 18.98%, respectively. Unknown behaviors remained low at 3.00%. In Phase C, wakefulness remained similar to Phase B (45.21%), resting increased to 22.28%, sleep decreased to 22.59%, and unknown behaviors increased to 9.91%. Despite the variation in the proportion of time spent on different behaviors, Kruskal–Wallis tests between phases did not find significant results for overall duration of behaviors ($P > 0.05$).

Table 2: Ethogram (adapted from [20] and [21]).

Category	Behaviors included
Wakefulness: Standing Sternal recumbency	Ear position and/or frequency of body or limb movement indicates the horse is alert. Includes eating, moving, excreting, rolling, etc. Eye is open.
Resting: Standing Sternal recumbency	Standing active with movement that shifts balance or changes resting limbs, with small, frequent ear and/or head movements observed. Standing inactive, with no movement of the body, but small ear and/or head movements observed. Sternal recumbency with small, frequent ear and/or head movements observed; muzzle is not in contact with the ground.
Sleep: Standing sleep Sternal recumbency Lateral recumbency	In all cases no, limited, or slow ear/eye movement: Standing immobile, with the top of the head between the ears (poll) equal to or below the withers (with or without a resting hind limb). Lying immobile with the sternum in contact with the ground and legs folded beneath the body; muzzle may or may not be in contact with the ground. Lying immobile on the side (lateral thoracic area parallel to and in contact with the ground), legs extended, head on the floor and immobile other than ear and/or eye movement, with some involuntary limb movement (indicative of REM sleep).
Unknown	Where the observer cannot determine which behavior is being displayed, for example, if the horse's head is over the door and there is not enough movement to suggest it is awake, but the head cannot be seen to determine whether it is asleep

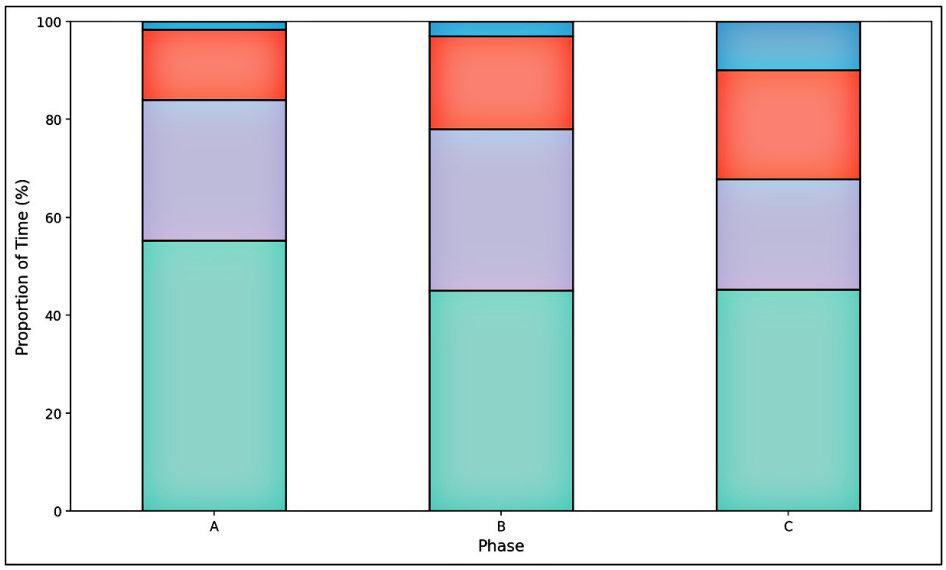

Figure 1: Behavioral budget of observed horses (N = 5) during nocturnal observation across three phases of the study: Phase A (normal exercise), Phase B (increased exercise), and Phase C (returning to baseline exercise). Different colors illustrate the different behaviors observed (green = Wakefulness, purple = Sleep, red = Resting, and blue = Unknown).

3.2. Effect of Different Phases on Sleep Bouts and Sleep Posture

Sleep bouts increased in both duration and frequency with increased exercise. Mean bout durations were 5.33 ± 10.99 min (0.13–67.05, n = 216) in Phase A, 10.79 ± 13.15 min (0.08–86.92, n = 388) in Phase B, and 8.98 ± 13.08 min (0.20–91.65, n = 451) in Phase C. Total sleep time increased from 19.2 h in Phase A to 69.8 h in Phase B and remained high at 67.5 h in Phase C. The number of sleep bouts also increased, from 216 in Phase A to 388 in Phase B and 451 in Phase C, indicating both more frequent and longer sleep episodes. A Kruskal–Wallis test confirmed significant differences in sleep bout duration across phases ($H(2) = 81.87$, $df = 2$, $P < 0.001$), and post hoc tests confirmed that Phase B bouts were significantly longer than Phase A ($P < 0.001$), and Phase C bouts were also significantly longer than Phase A ($P < 0.001$). There was no significant difference between Phases B and C ($P > 0.05$) (**Figure 2**).

Resting bouts showed a similar pattern, with mean durations of 1.30 ± 2.21 min (0.03–34.23, n = 443) in Phase A, 6.46 ± 12.03 min (0.07–72.92, n = 250) in Phase B, and 5.30 ± 10.16 min (0.17–80.17, n = 461) in Phase C. Total resting time increased from 9.6 h in Phase A to 26.9 h in Phase B and 40.7 h in Phase C, with both Phases B and C being significantly different from Phase A ($H(2) = 259.9$, $P < 0.001$). Wakefulness bouts remained similar in duration between phases: 4.01 ± 12.23 min (0.03–133.97, n = 553) in Phase A, 5.88 ± 11.45 min

(0.08–99.8, n = 334) in Phase B, and 5.36 ± 11.46 min (0.05–85.0, n = 469) in Phase C; no statistical differences were found ($P > 0.05$).

Sleep postures were affected differently during the exercise phases (**Figure 3**). **Table 3** presents descriptive statistics for sleep bout durations across various postures and phases. Sternal recumbency sleep (SSR) was the most common sleep posture (n = 665 bouts), followed by standing sleep (SS, n = 559 bouts) and lateral recumbency sleep (LRS, n = 181 bouts).

The mean SSR bout duration increased significantly from 1.8 min in Phase A to 7.1 min in Phase B, then decreased to 5.0 min in Phase C ($H(2) = 35.21$, $P < 0.001$), indicating a notable post-exercise change in sternal sleep patterns. LRS bouts showed a similar but less pronounced trend, increasing from 3.1 min (Phase A) to 6.6 min (Phase B) and slightly decreasing to 5.8 min (Phase C). Although this pattern suggested a temporary effect on lateral recumbent sleep during the exercise phase, the effect did not reach statistical significance ($H(2) = 5.91$, $P = 0.051$). In contrast, SS bout durations exhibited a variable pattern, decreasing from 12.5 min (Phase A) to 7.7 min (Phase B) and rising modestly to 8.7 min (Phase C). This change was statistically significant ($H(2) = 6.49$, $P = 0.007$), indicating a redistribution of sleep across postures rather than a consistent increase or decrease in standing sleep duration.

Overall, horses spent 80.7 h in SS, 53.8 h in SSR, and 17.2 h in LRS across all phases, representing approximately 50.2%, 33.5%, and 16.3% of total observed sleep time, respectively.

Post-hoc Mann–Whitney U tests with Bonferroni correction ($\alpha = 0.017$) for SSR further demonstrated that Phase B had significantly longer bout durations compared to Phase A ($U = 9{,}683.50$, $P < 0.001$). Phase C also showed significantly longer durations than Phase A ($U = 7{,}324.00$, $P = 0.003$). Phase B and Phase C did not differ significantly from each other ($P = 0.069$).

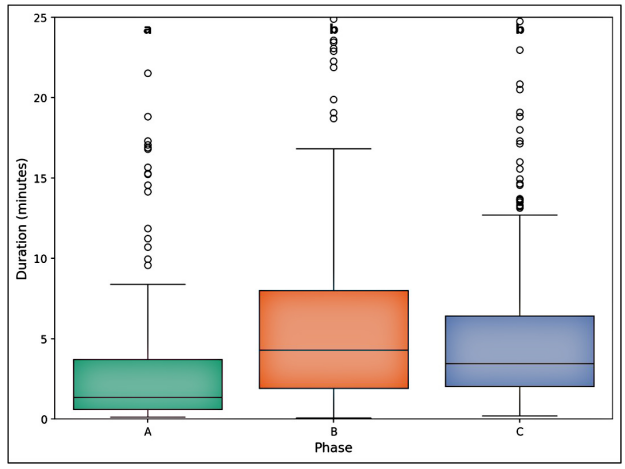

Figure 2: Differences in sleep bout durations in the observed horses (N = 5) across the three study phases: Phase A (normal exercise), Phase B (increased exercise), and Phase C (returning to baseline exercise). The line indicates the median, whiskers show the maximum and minimum values, and the box displays the interquartile range. Different letters denote significant differences set at $\alpha = 0.05$.

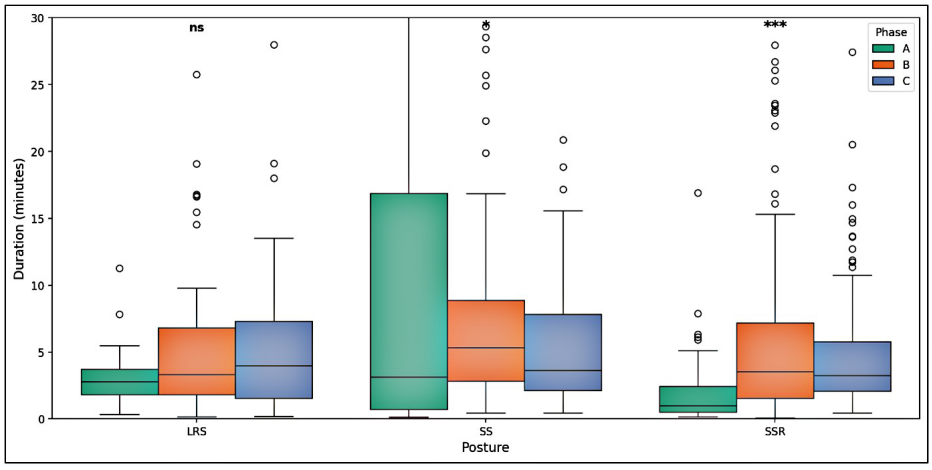

Figure 3: Sleep bout duration distributions by posture across phases in the observed horses (N = 5) during the three study phases: Phase A (normal exercise), Phase B (increased exercise), and Phase C (returning to baseline exercise). The line indicates the median, whiskers show the maximum and minimum values, and the box displays the interquartile range. Star indicates significant level $^{*}P < 0.05$, $^{***}P < 0.01$, ns = non-significant. LRS = Lateral recumbency sleep, SS = standing sleep, SSR = Sternal recumbency sleep.

Table 3: Descriptive statistics for sleep bout duration by posture and phase across the three study phases: Phase A (normal exercise), Phase B (increased exercise), and Phase C (returning to baseline exercise), observed in five horses over the course of the study.

Posture	Phase	N Bouts	Min (min)	Max (min)	Mean (min)	SD (min)	Median (min)
Lateral Recumbency Sleep (LRS)	A	28	0.32	11.25	3.13	2.27	2.78
	B	68	0.17	54.27	6.62	9.84	3.30
	C	85	0.20	38.63	5.77	7.45	3.97
Standing Sleep (SS)	A	68	0.13	67.05	12.45	17.39	3.12
	B	249	0.27	58.63	7.74	9.66	5.40
	C	242	0.23	90.35	8.69	11.87	3.63
Sternal Recumbency Sleep (SSR)	A	114	0.17	16.90	1.80	2.13	1.00
	B	227	0.08	84.58	7.06	10.40	3.55
	C	284	0.30	62.42	5.00	6.39	3.25

Note: N = total number of bouts recorded across all observed horses per phase; Min = duration in minutes.

4. Discussion

This observational study sought to determine whether wakefulness, rest, and sleep-related patterns of behavior were significantly different when horses were subjected to differing exercise regimens, where Phase B involved increased levels of exercise. Across all phases, horses spent approximately half of the observed period awake, with the remaining time divided between resting and sleep-related behaviors. While total proportions of wakefulness, rest, and sleep did not differ significantly between phases, the structure and organization of sleep behavior, particularly bout frequency and posture-specific durations, did vary. The observed changes in sleep structure may indicate a subtle adaptive recovery process that could directly impact the horses' physiological recovery. Longer and more frequent sleep bouts can enhance muscle recovery and energy restoration [27–29], as well as support cognitive processing and alertness, which may directly impact performance and overall well-being [12,29]. Horses might adjust resting patterns in response to increased workload to aid physical recovery and prepare for upcoming activity. This highlights the importance of considering sleep architecture, rather than only total sleep time, in equine management.

There is a general expectation across species that increased daytime physical activity improves subsequent sleep, both in quality and consolidation (e.g., humans [30], mice [31], rats [32], dogs [33]). Consistent with this, horses have been shown to rest more after training days [17]. In addition, horses in Phase B of the current study exhibited a greater proportion of rest and sleep-related behaviors compared with Phases A and C, even though total time spent in these states did not change significantly. This suggests that exercise may promote sleep-favorable behaviors, aligning with findings in humans where physical exertion enhances slow-wave sleep and improves sleep continuity [34,35]. This pattern of increased sleep in Phase B may also be a reflection of a sleep rebound response, a homeostatic mechanism triggered by increased physical activity and cognitive demands [36]. Exercise increases metabolic energy expenditure, depletes glycogen stores, and causes microdamage to the muscles and connective tissues, all of which necessitate restorative processes during sleep [27–29,34,35]. More consolidated sleep also facilitates neurocognitive restoration and hormonal regulation [29], which are important for maintaining alertness, learning, and overall functional performance after intensive activity [6,12,28,34], particularly relevant to horses engaged in training and competitive work [13–15]. Collectively, these mechanisms suggest that the longer and more frequent sleep bouts seen in Phase B reflect an adaptive, rebound-like response that supports recovery processes, similar to what has been reported in other species following increased activity or sleep deprivation [30–33,36,37].

When considering the proportion of total observation time spent on behavioral states, increased exercise appeared to lead to a higher proportion of sleep-related behaviors and rest, despite the lack of a significant difference between phases. Cumulative duration data, similar to proportional data, derived from state behavior occurrence, have been considered less sensitive as a useful measure of sleep [38]. Analyzing bout duration and frequency offered more detailed representations of sleep structure, highlighting how horses experienced more frequent and longer sleep episodes during Phase B that were significantly different from Phases A and C. This pattern was consistent across measures, suggesting an adaptive change to sleep behavior in response to higher physical load. Moreover, the increase in bout duration and frequency in Phase C suggests a delayed recovery process, possibly reflecting ongoing physiological adaptation or incomplete recovery after intense exercise. While direct studies on prolonged changes in equine sleep in response to exercise are limited, existing evidence in humans demonstrates that sleep patterns can remain altered for several days following intense physical activity [39,40]. In addition, sleep quality was not measured in this study, and although total sleep time increased, this is not necessarily indicative of high-quality sleep, which could also explain the delayed recovery process [38].

Wakefulness bout frequency and duration did not differ between phases, implying that vigilance and environmental awareness were maintained. This pattern may reflect a species-specific balance: as prey animals, horses rarely exhibit

prolonged periods of deep, unguarded sleep [37,41]. The simultaneous increase in resting behaviors alongside sleep supports the idea of rest–wake redistribution, wherein horses adaptively allocate inactive time to support recovery without compromising essential alertness [15,42]. Furthermore, the increase in "unknown" behaviors during Phase C may reflect anticipatory or vigilance-related activities, such as standing alert near stable doors, potentially associated with feeding or routine changes. These observations underscore the interaction between sleep demand and environmental opportunities for rest, emphasizing the critical role of stable management and predictability in promoting natural equine sleep behaviors. In relation to sleep, previous studies in farm animals have demonstrated that positive, predictable handling and management are associated with lowered arousal and increased restfulness in a range of species, while frequent disturbances or unpredictable interactions can fragment sleep and elevate vigilance behaviors [43]. Likewise, in companion species, studies have shown that owner presence and interaction can alter sleep timing and architecture, and routine and predictability critically affect the likelihood of undisturbed REM sleep [44]. In the present context, increased exercise likely changed both the horses' physiological load and their daily routines (e.g., timing of handling, turnout, grooming, tack changes), which in turn can alter arousal and sleep opportunity. Thus, when interpreting changes in sleep patterns, concurrent measures of human–animal interactions and stable routines should be considered to separate physiological recovery from management-driven changes in opportunity and disturbance.

For horses, posture correlates well with sleep stage, for example, SSR with non-REM and LRS with REM [38]. Monitoring these postures may offer a behavioral proxy for assessing sleep. Posture-specific analysis provided further insight into how horses reorganize sleep architecture following exercise. During Phase B, both Sternal Recumbency Sleep and Standing Sleep bouts increased in duration, indicating more consolidated non-REM and states of drowsiness. Meanwhile, Lateral Recumbency Sleep, typically associated with REM sleep, showed a modest and non-significant change, suggesting that REM sleep may be less influenced by exercise intensity. Overall, these findings suggest that exercise primarily alters sleep quality rather than total sleep quantity, promoting more efficient recovery phases [35,45,46]. Similar compensatory sleep dynamics have also been observed in human athletes [47] and rodents [31] subjected to a change in exercise regimen, where physical exertion enhances slow-wave sleep and stabilizes sleep–wake cycles, but in these cases without necessarily increasing total sleep duration. The differences in sleep postures compared to lateral recumbent sleep may relate to physiological mechanisms underlying behavioral changes, such as homeostatic regulation of energy balance and muscle recovery. Exercise increases metabolic expenditure, thermoregulation demands, and muscular strain, which all elevate sleep drive and non-REM sleep pressure [47–49]. The transition toward longer, more consolidated bouts of SSR and SS in Phase B could be reflective of adaptive recovery behavior, whilst the reduced duration spent in LRS compared to other sleeping postures may be associated with factors that are not directly related to exercise. Given the importance of lateral recumbency for REM sleep in horses, reductions in this posture could compromise restorative sleep, potentially impacting muscle recovery, immune function, and cognitive processes involved in learning and performance [37,50].

From a management perspective, these findings highlight the importance of carefully considering exercise intensity and scheduling, as they are key factors affecting rest and recovery. Extensive or vigorous exercise can disrupt sleep architecture, impacting physical recuperation, thermoregulation, and cognitive functions [47,51]. Optimizing exercise schedules and stable management to align with natural sleep and rest patterns can reduce stress and fatigue, while simultaneously supporting training efficiency and performance outcomes. To support restorative sleep and facilitate adaptive recovery, providing stable conditions such as quiet, comfortable bedding, controlled lighting, and consistent routines is essential [38,52].

4.1. Limitations and Future Directions

Some limitations of the present study should be considered when interpreting the findings. First, behavioral observation alone cannot definitively determine sleep stages or detect micro-arousals. While posture provides a useful proxy for differentiating non-REM and REM sleep [38], subtle sleep fragmentation or arousal events may have gone unnoticed. Additionally, although increased total sleep time is often seen as beneficial, it does not necessarily indicate better recovery if accompanied by fragmentation. Fragmented sleep (characterized by frequent arousals or transitions) can reduce sleep restorative value even when overall duration remains the same [53]. In this study, the observed increase in mean bout duration suggests greater consolidation rather than disruption; however, micro-arousals could not be ruled out without electrophysiological measures. Combining behavioral data with electroencephalography (EEG) or actigraphy in future research would allow for more precise classification of sleep depth and quality, offering a clearer understanding of recovery processes following exercise [38,54].

The small sample size (n = 5), along with incomplete participation across some phases, also limit the generalizability of the findings. As observed in different animal species, sleep patterns may vary across breeds [55] and ages [56], given differences in metabolic capacity [57], musculoskeletal development [50], and stress reactivity [58], all of which in turn can affect sleep response to exercise regimen. For example, younger horses may exhibit greater physiological plasticity and more robust sleep rebound responses following increased exercise. Similarly, temperament, familiarity with handlers, and prior training experience may influence responses [44,59,60], especially under the conditions found in Phase B, when both exercise intensity and human–animal interaction increased. Furthermore, the horses in this study were managed in a stable-based, domestic environment; feral or pasture-kept horses, which experience different environmental pressures, social dynamics, and opportunities for rest, may display distinct sleep and recovery responses to physical activity, similar to changes in sleeping patterns observed in wild species [61]. Future studies with larger, more diverse samples are needed to capture individual variability better and strengthen statistical validity.

Increased exercise in this study involved increased human–horse interaction on the ground and not during ridden work. While physical activity and interaction can enrich behavioral experiences, excessive or poorly managed contact may contribute to cognitive or emotional fatigue, particularly in therapeutic or training contexts [62,63]. Physiological indicators of recovery, such as heart rate variability, cortisol levels, or muscle enzyme activity, were not included in this study. Including these alongside behavioral measures would offer a more comprehensive assessment of how exercise and human–animal interaction affect equine recovery and welfare [51,64–66]. Furthermore, systematic evaluation of human–animal interaction intensity, including duration, type, and frequency of handling or training, could clarify how cognitive or emotional demands interact with physical workload to influence equine sleep and rest patterns [43,65].

Finally, although partially controlled, environmental and management variables were not consistently measured in our dataset. Factors such as stable layout, noise levels, lighting, and bedding depth can all significantly affect rest behavior and sleep patterns in horses. Additionally, since this study focused solely on nocturnal sleep, diurnal resting and napping behaviors were not recorded. Future research should, therefore, implement continuous 24-hour monitoring to capture the complete cycle of rest, sleep, and wakefulness in relation to exercise routines and management strategies. Combining continuous behavioral, physiological, and environmental data across larger and more diverse populations will improve ecological validity and offer stronger evidence to better inform management practices in domestic horses.

5. Conclusion

This study shows that changes in exercise result in changes to the way horses sleep, not just how much they sleep. Longer periods of physical activity and interaction with humans appear to be able to significantly change sleep patterns. In such situations, horses engage in longer and more frequent sleep bouts at night, indicating an adaptive response to exercise to meet recovery needs. The fact that longer sleep durations persist after exercise suggests that recovery extends beyond immediate training sessions. These findings highlight the importance of considering exercise schedules, rest periods, and environmental conditions in equine welfare practices. Ensuring proper conditions for restful sleep and recovery is vital for the well-being of horses, especially in high workload or therapeutic settings. Incorporating these insights into management strategies can enhance the welfare and performance of domestic horses, linking behavioral ecology with practical equine management.

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Authors' Contributions

I.S.: Conceptualization, Methodology, Data curation, Formal analysis, Validation, Writing – original draft, Writing – review & editing. L.G.: Conceptualization, Methodology, Data curation, Writing – original draft, Writing – review & editing. M.L.: Data curation, Resources, Writing – review & editing. L.C.: Data curation, Resources, Writing – review & editing.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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This study has not received any funding.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

Ethical approval was granted by the Hartpury Ethics Committee (ETHICS2022-118). The authors confirm that the study has followed the guidelines of the Declaration of Helsinki.

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