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Effect of exercise on equine behavior

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ABSTRACT

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The effect of short periods of strenuous exertion, in this case treadmill exercise, on the subsequent behavior of Standardbred horses was examined. Six horses were exercised on a high-speed treadmill 4 or 5 days per week, for 3–4 miles (approximately 1.8 m s^{-1} for 3 min, 5 m s^{-1} for 12 min, 9 m s^{-1} for 3 min, 3 m s^{-1} for 3 min, 1.8 m s^{-1} for 3 min). The behavior of the horses was observed in the horse's home stall immediately after exercise and 2–7 h after exercise. Focal animal sampling for a total of 150 h revealed that the horses spent significantly more time drinking and less time resting after exercise than they did on control (non-exercise or rest days). The greatest influence on behavior was seen immediately after exercise. The horses spent 13.2 ± 2.7 s per 15 min drinking after exercise and 7.2 ± 2.3 s per 15 min drinking on non-exercise days. They spent 7.3 ± 1.5 min h^{-1} stand resting after exercise and 9.7 ± 2.1 min h^{-1} on non-exercise days. These changes in behavior may be related to the physiological changes that accompany exercise. Eating, walking, elimination and self-grooming were not significantly influenced by exercise.

In a second experiment the activities of two groups of six Standardbred mares were compared. One group was exercised on the treadmill and the other was not. The exercised horses spent more time drinking and lying, but urinated less than the non-exercised group.

INTRODUCTION

In the last 20 years, there has been a great increase in our knowledge of the effects of exercise on equine physiology and nutrition. Cardiovascular and respiratory physiology has been investigated (Snow et al., 1983; Gillespie and Robinson, 1987), but the influence of exercise on behavioral patterns, such as resting, food intake and water balance, has received less attention. The purpose of the study was to determine whether horses behaved differently on days when they were exercised than on days when they rested. We were particularly interested in drinking behavior because McKeever et al. (1987) re-

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ported that horses in training increase their blood volume, but do not increase their water intake. We wished to determine whether horses drank more frequently by using each animal as its own control and determining whether their behavior was different on exercise days than on rest days. In addition to the effects on drinking, the effects on other behaviors were also of interest. After exercise, horses could respond by resting more, thereby expending less energy. Alternately, the horses might be more active in their stalls in response to the catecholamines released during exercise (Snow et al., 1979). Feeding behavior was also measured because the horses might either eat more to compensate for the energy expended or show exercise-induced anorexia, i.e. eat less (Crews et al., 1969; Guilland et al., 1988). The aim of this study was to compare the time budgets of horses after exercise in order to reveal differences in time spent feeding, drinking, standing, resting and other behavioral patterns owing to physical exertion. Finally, these data can be used to compare the time budgets of stalled horses with those of free-ranging horses (Duncan, 1980; Keiper, 1981; Berger, 1986).

ANIMALS, MATERIALS AND METHODS

The study consisted of two parts: (1) between horses, comparison between two groups of horses, one exercised and the other not; (2) within horses, comparison of the behavior of horses on days when they were exercised and days when they were not.

Between horses

Twelve Standardbred mares were observed from August to October, 1987. Six mares (mean weight, 501.3 ± 20.6 kg; mean age, 9.7 ± 1.6 years) were not exercised. Six mares (mean weight, 448 ± 16 kg; mean age, 4 ± 1 years) were exercised on a high-speed treadmill (Sato Inc., Uppsala, Sweden) five times a week. The exercise period was 30 min in duration, including 5 min for warm-up and cool down at a walk. The remaining 20 min were spent at an extended trot, a sub-maximal gait for all of the horses. Each group was housed in a grassless paddock with access to run-in stalls. One half of a bale (approximately 9 kg) of mixed timothy hay was fed to each horse per day. A sweetened mixed grain ration was fed in a quantity sufficient to maintain body weight which was about 2–3 kg per mare day^{-1}.

Fifteen-minute focal samples were used to collect the data (Altmann, 1974). The behavior of each horse and the time of initiation of each behavior lasting at least 5 s were recorded with a stopwatch, so that the minutes spent in each activity state could be calculated. The 14 behaviors recorded at the time of the visual scans were as follows.

(1) Eating: prehending, masticating or swallowing food.
(2) Drinking.

(3) Standing with head raised or moving, eyes fully open and ears oriented in the same direction.

(4) Stand resting: Noted when at least three of the following five criteria were observed:

(a) head held so top of head lower than the withers;

(b) ears pointing in different directions or lying back in a relaxed position;

(c) one hind limb flexed so the weight was carried by the other three;

(d) lower lip hanging relaxed;

(e) eyes partly or fully closed.

(5) Standing alert.

(6) Walking.

(7) Defecating.

(8) Urinating.

(9) Self-grooming: licking body surface, nibbling or scraping of the skin, scratching one part of the body against another (foot and head), and rubbing skin against another surface of the body or against some object in the environment and rolling over.

(10) Lying sternal: lying down on the sternum, legs folded under the body.

(11) Lying lateral: lying on its side, with its head and leg outstretched.

(12) Mouthing: chewing wood of stalls, chewing feed buckets and licking.

(13) Vocalization.

(14) Social interaction.

These definitions are based on those of Crowell-Davis (1985) and Boyd (1988). Student's *t*-test was used to determine significance of differences in behavior between exercised and non-exercised horses.

A slightly different procedure was used to observe the horses at night. A scan sample was taken every 15 min for several hours each night between 11:00 and 04:00 h for 10 nights. The observer walked through the paddocks using a flashlight when necessary to identify the horses. The posture of the horses (standing, lying lateral or lying sternal) was recorded. Each horse was observed from 122 to 216 (mean of 174.3 ± 13.6) times. The Mann–Whitney *U* test was used to determine differences in lying between exercised and non-exercised horses.

The differences in behavior, particularly in drinking, between horses that were exercising and those that were not, led us to investigate the effects of exercise within the same animals. We were interested in the immediate effects of exercise. For that reason, horses were observed on days when they were exercised and on days when they were not.

Within horses

Six Standardbred horses, two geldings and four mares (3–5 years of age), were observed from the middle of June 1989 to the end of August 1989. Each horse was confined in a 2.7 m$\times$3.5 m box stall in a temperature-controlled stable (24–27°C). Visual and physical contact with horses in adjacent stalls was possible.

An ultrasonic blood flow meter had been surgically implanted around the bronchial artery of each horse in order to measure bronchial artery blood flow during exercise (Dobson et al., 1987). Each horse had been adapted to the treadmill for several weeks before the study began. They were exercised on a treadmill (Sato Swedish high-speed treadmill) 4 or 5 days per week, for 3–4 miles (approximately 1.8 m s^{-1} for 3 min, 5 m s^{-1} for 12 min, 9 m s^{-1} for 3 min, 3 m s^{-1} for 3 min, 1.8 m s^{-1} for 3 min). This exercise schedule was maintained throughout the entire observation period. Immediately after exercise each horse was hosed down with water for approximately 5 min.

Fifteen-minute focal samples of the horses' behavior were made as described above. Observations were made between 08:00 and 18:00 h: (1) pre-exercise; (2) immediately after exercise; (3) 2–3 h and 6–7 h after exercise; (4) at the same times on days when the horse was not exercised. Two to four samples were taken on each horse each day. An equal number of observations were made on non-exercise days as on exercise days. One hundred and forty-five total hours of focal observations were made (four horses for 30 h, one horse for 8 hours, and one horse for 17 h).

Grain was fed at 06:00 h in the morning. Hay was fed twice a day (08:00 and 15:00 h). Hay was always available during the observation periods, water was provided ad libitum in buckets and the horses had free access to salt blocks.

The data were stored and the total number of seconds spent in each behavior per 15 min observation period was calculated using a program developed for use on a microcomputer (Apple II) (Boyd, 1988). *t*-Tests were used to compare the duration of each behavior under each condition. The following comparisons were made: (a) immediate effects, data taken immediately after exercise with the same time of a non-exercise day; (b) delayed effects, 2–7 h after exercise with the same times on a non-exercise day; (c) overall effects, all data taken on an exercise day with all data of a non-exercise day. For each horse for each behavior a *t*-test for two independent samples was calculated. When the P values of the individual horses were obtained, Fisher's method of combining tests was used to calculate the significance for all the horses (Winer, 1962). For (a) and (b) only five horses were used; there were insufficient data available for the sixth horse.

RESULTS

Between horses

The greatest differences were seen in behaviors related to fluid balance. The exercised horses spent 31.1 (mean) $\pm$ 5.6 (SEM) s h^{-1} drinking, whereas the non-exercised horses spent 8.6 ± 2.4 s h^{-1} ($t=3.57$, $P<0.01$) (Fig. 1). The exercised horses spent 1.4 ± 0.8 s h^{-1} urinating; the non-exercised horses spent 6.4 ± 1.6 s h^{-1} urinating ($t=2.61$, $P<0.04$).

There were significant differences in feeding behavior (Fig. 2). The exercised horses spent 19.2 ± 2.2 min h^{-1} eating hay; the non-exercised horses spent 11.0 ± 1.9 min h^{-1} ($t=2.89$, $P<0.02$). The exercised horses spent 18.5 ± 3.1 min h^{-1} grazing; the non-exercised horses spent 28.7 ± 2.6 min h^{-1} ($t=2.53$, $P<0.02$). There was no significant difference in overall time spent eating (grazing plus eating hay).

There were no significant differences in walking (exercised, 3.1 ± 0.3 min h^{-1}; non-exercised, 2.8 ± 0.4 min h^{-1}) or standing (exercised, 16.9 ± 3.1 min h^{-1}; non-exercised, 18.4 ± 1.7 min h^{-1}).

The exercised horses spent significantly more time at night lying down

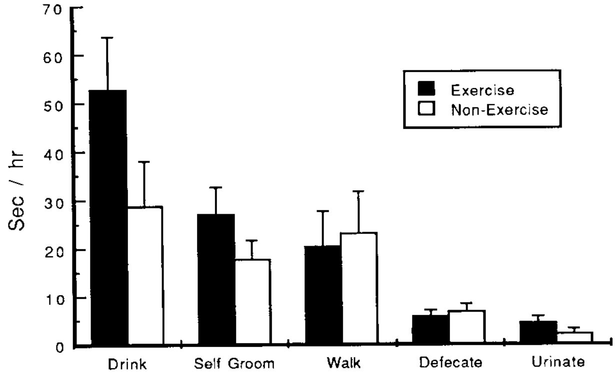

Fig. 1. Differences in minor behavior of exercised and non-exercised horses in paddocks. The vertical line indicates the standard error of the mean of the six horses in each group.

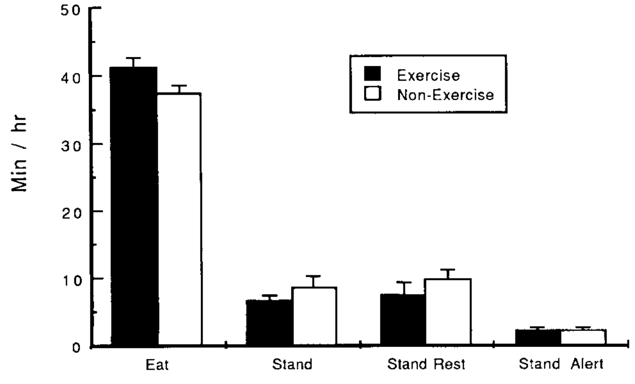

Fig. 2. Differences in major behavior of exercised and non-exercised horses in paddocks. The vertical line indicates the standard error of the mean of the six horses in each group.

(13.2 ± 2.1% of the observations of each horse) than the non-exercised horses (5.8 ± 3.6; $P < 0.05$).

Within horses

Drinking

Immediately after exercise the horses spent significantly more time drinking than at the same time on a non-exercise day ($P < 0.001$, see Fig. 3). There was no significant delayed effect of exercise (exercise days, 6.2 ± 1.9 s per 15 min; non-exercise days, 7.4 ± 2.7 s per 15 min; see Fig. 4), but overall the horses spent significantly more time drinking on exercise days than on non-

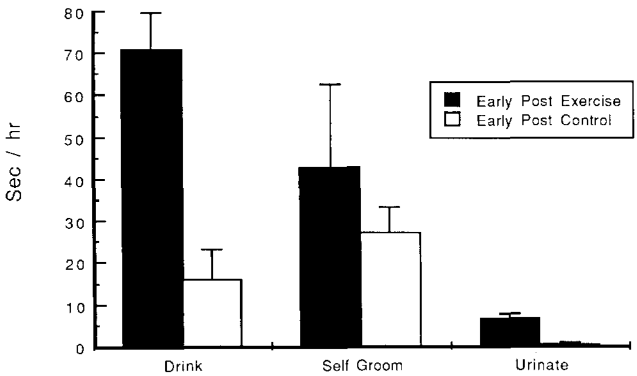

Fig. 3. Changes in drinking, self grooming, and urinating in stalled horses immediately after exercise. The vertical lines indicate the standard error of the mean of the six horses. The horses were observed at the same times on non-exercise days.

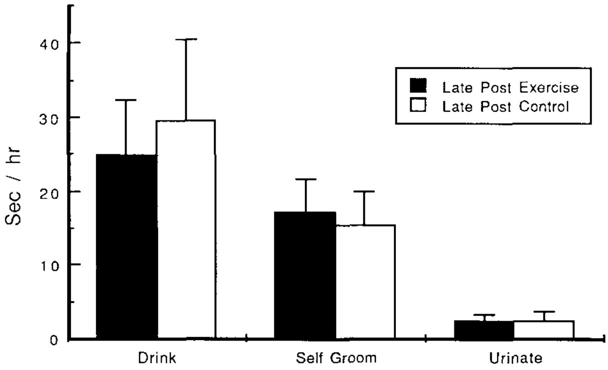

Fig. 4. Changes in drinking, self-grooming, and urinating in stalled horses 2—6 h after exercise. The vertical lines indicate the standard error of the mean of the six horses. The horses were observed at the same times on non-exercise days.

exercise days (exercise days, 13.2±2.7 s per 15 min; non-exercise days, 7.2±2.3 s per 15 min; $P<0.05$).

Standing

Stand resting. Significantly less time was spent stand resting immediately after exercise than on non-exercise days ($P<0.02$, see Fig. 5). There was no delayed effect of exercise (exercise days, 146±45 s per 15 min; non-exercise days, 133±27 s per 15 min, see Fig. 6), but there was a trend overall for the horses to spend less time stand resting on exercise days than on non-exercise days (exercise days, 109±22 s per 15 min; non-exercise days, 145±31 s per 15 min).

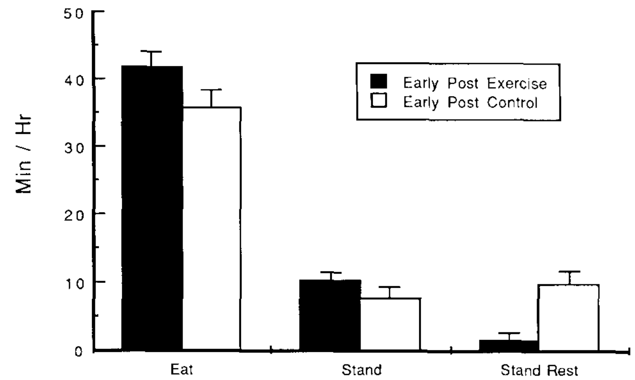

Fig. 5. Changes in standing and eating behavior in stalled horses immediately after exercise. The vertical lines indicate the standard error of the mean of the six horses. The horses were observed at the same times on non-exercise days.

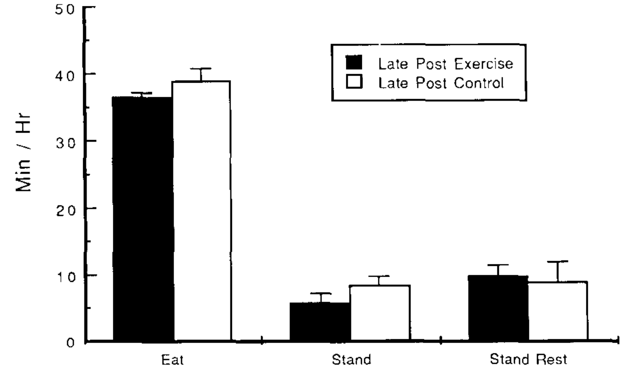

Fig. 6. Changes in standing and eating behavior in stalled horses 2–6 h after exercise. The vertical lines indicate the standard error of the mean of the six horses. The horses were observed at the same times on non-exercise days.

Standing alert. Time spent standing alert was similar on exercise and non-exercise days. Overall the horses spent 30.4 ± 9 s per 15 min standing alert on exercise days and 31.3 ± 9 s per 15 min on non-exercise days.

Standing (neither resting nor alert). Immediately after exercise there was a trend for the horses to spend more time standing than they did on non-exercise days (see Fig. 5). The delayed effect of exercise was to reduce standing time (see Fig. 6) so that the overall time spent standing did not differ between exercise days and non-exercise days (exercise days, 89.5 ± 10 s per 15 min; non-exercise days, 119 ± 24 s per 15 min).

Eating

There was no significant effect on eating, although there was a trend for the horses to spend more time eating immediately after exercise than on non-exercise days (exercise days, 624.2 ± 38 s per 15 min; non-exercise days, 535.6 ± 18 s per 15 min; see Fig. 5). There was neither a delayed (exercise days, 617 ± 21 s per 15 min; non-exercise days, 559 ± 31 s per 15 min; see Fig. 6) nor an overall effect of exercise on eating.

Urinating and defecating

The horses tended to spend more time urinating immediately after exercise (see Fig. 3). There was no delayed effect (see Fig. 4). Overall horses seemed to spend more time urinating on days being exercised (exercise days, 1.1 ± 0.3 s per 15 min; non-exercise days, 0.5 ± 0.2 s per 15 min). The amount of time spent defecating did not differ with exercise (exercise days, 1.4 ± 0.4 s per 15 min; non-exercise days, 1.6 ± 0.3 s per 15 min).

Self-grooming

Immediately after exercise, horses tended to groom themselves more than on non-exercise days (see Fig. 3). There was no delayed effect of exercise (see Fig. 4), and there was no significant overall effect (exercise days, 6.7 ± 0.9 s per 15 min; non-exercise days, 4.4 ± 1.4 s per 15 min).

Walking

Although there were some significant differences in time spent walking by individual horses when exercised or at rest there were no significant effects when the P values were combined. Overall the horses spent 5.7 ± 2.2 s per 15 min walking in their stalls after exercise and 5.1 ± 1.8 s per 15 min on non-exercise days.

There were no significant differences in duration of mouthing, vocalization and social interactions between exercise and non-exercise days. Lying was rarely observed.

DISCUSSION

The most marked changes seen were in ingestive behavior and resting behavior. The time spent drinking increased significantly immediately after exercise, presumably in order to compensate for fluid loss in sweat. One of the physiological changes accompanying exercise is hypovolemia as reflected in an increase in plasma protein (Carlson, 1987). Horses have already been shown to drink in response to hypovolemia whether caused by simple water deprivation or by administration of the diuretic furosemide (Sufit et al., 1985), so it is not surprising that they drink in response to exercise-induced hypovolemia.

Our results are in contrast to those of McKeever et al. (1987), who did not note a change in water intake in exercising horses. They did not offer the horse water ad libitum, but rather presented buckets four times a day. That schedule and the fact that the horses in the present study were given hay rather than a limited amount of cubed feed as in the McKeever et al. study could account for the differences in results. In the present study, water intake was not measured directly so that the possibility exists that the horses were not drinking more, but rather were drinking more slowly. The study should be repeated under conditions where water intake could be measured.

Hypervolemia accompanies adaptation to exercise in a variety of species. In man (Greenleaf et al., 1983) and in Greyhound dogs (McKeever et al., 1985) the rate of water intake increases significantly with exercise training. There are two methods by which hypervolemia can occur: a decrease in urine output or an increase in water intake. McKeever et al. (1987) found that urine output decreased in the horse so they hypothesized that a decrease in output rather than an increase in intake accounted for the hypervolemia. Meyer (1987) also found that renal water and sodium excretion is significantly reduced during and after exercise periods. In contrast, Snow et al. (1982) observed that the rate of urine formation during endurance rides is not significantly different from that occurring in the same horses at rest. These results may indicate differences in response to long, sub-maximal and short, maximal periods of exercise. There may also be a conditioning effect in that McKeever et al.'s horses were studied as they began training rather than when conditioned. The decrease in urine output was measured directly by McKeever et al. (1987) and indirectly in this study and the increase in water intake is measured indirectly in this study. The hypervolemia may help to offset the acute hypovolemia that results from short periods of strenuous exercise.

In addition to an increase in plasma protein, an increase in hematocrit has also been observed following exercise (Harris, 1987). This increase in hematocrit reflects not only hypovolemia, but also release of red blood cells from the spleen. Epinephrine levels are increased during exercise (Snow et al., 1979), and presumably stimulate both splenic contraction and the increase in general arousal of the horse after exercise. After exercise horses may be more likely to startle and, therefore, be more susceptible to stall injuries at that time.

More time was spent lying by the exercised horses in the between horse study. This could indicate that the horses were compensating for the energy expended during exercise. Note however, that the exercised horses were considerably younger than the non-exercised horses. It is well documented that sub-adult horses spend more time lying than adult horses (Duncan, 1980).

The increase in time spent eating in the between horse study could represent a compensation for the increased energy expended during exercise, but it may also have been an artefact of the management system. The non-exercised horses may have eaten their hay while the exercised horses were exercising. Hay was not available ad libitum. Intake should be measured directly to answer this question of the effect of exercise on intake.

The reason for the small increase in self-grooming after exercise is not known, but may be either a direct result of exercise (sweating and hyperthermia) or a response to the wetting of the coat that occurred when the horses were hosed down directly after exercise.

It should be noted that all of the changes in behavior observed occurred immediately after exercise; by 2–7 h after exercise the horses' behavior was indistinguishable from their behavior on non-exercise days.

The major difference between the behavior of these stalled and penned horses and free-ranging horses is in feeding time. Horses with access to forage spent most of the day grazing. The confined horses stood instead.

Although the behavior of free-ranging horses has been studied by a number of groups (Duncan, 1980; Keiper, 1981; Berger, 1986), there have been few studies of horses living in stalls. This is particularly surprising as many domestic horses (domestic horses represent the majority of horses) probably live in stalls. Most studies have been of prepartum mares at night (Houpt et al., 1986; Shaw et al., 1988). Sweeting and her colleagues (Sweeting et al., 1985; Sweeting and Houpt, 1987) have studied stalled ponies during the day, but the present study may be the first conducted on horses during the day. The presence of a bronchial artery flow meter did not seem to have an effect on the horses' behavior because they spent 61% (exercised horses, 67%) of their time eating and 32% standing (exercised horses, 26%). Sweeting found similar percentages for ponies as did Boyd (1988) for Przewalski horses in a variety of zoo enclosures.

In conclusion, exercise affects the behavior of horses, particularly in the first hour or two after exercise. The horses spend more time drinking and less time resting. These changes in behavior are probably responses to the fluid loss and catecholamine release, respectively, that occur during exercise. In the presence of ad libitum hay, the confined horse, like its free-ranging counterparts, spends the majority of its time eating.

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