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Cortisol release, heart rate and heart rate variability in the horse and its rider: Different responses to training and performance

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ABSTRACT

Although some information exists on the stress response of horses in equestrian sports, the horse-rider team is much less well understood. In this study, salivary cortisol concentrations, heart rate (HR) and heart rate variability (HRV), SDRR (standard deviation of beat-to-beat interval) and RMSSD (root mean square of successive beat-to-beat intervals) were analysed in horses and their riders ($n = 6$ each) at a public performance and an identical rehearsal that was not open to the public.

Cortisol concentrations increased in both horses and riders ($P < 0.001$) but did not differ between performance and rehearsal. HR in horses and riders increased during the rehearsal and the public performance ($P < 0.001$) but the increase in HR was more pronounced ($P < 0.01$) in riders than in their horses during the public performance (from 91 ± 10 to 150 ± 15 beats/min) compared to the rehearsal (from 94 ± 10 to 118 ± 12 beats/min). The SDRR decreased significantly during the equestrian tasks in riders ($P < 0.001$), but not in their horses. The RMSSD decreased in horses and riders ($P < 0.001$) during rehearsal and performance, indicating a decrease in parasympathetic tone. The decrease in RMSSD in the riders was more pronounced ($P < 0.05$) during the performance (from 32.6 ± 6.6 to 3.8 ± 0.3 ms) than during the rehearsal (from 27.5 ± 4.2 to 6.6 ± 0.6 ms). The study has shown that the presence of spectators caused more pronounced changes in cardiac activity in the riders than it did in their horses.

Introduction

The stress response of horses to challenges during equestrian sports has prompted increasing research interest. Stressful stimuli initiate hypothalamo–pituitary–adrenocortical, adrenomedullary and sympathetic nervous system responses. During short-term stress, increased cortisol release may improve fitness by energy mobilisation (Reynaert et al., 1976) and changes in behaviour (Korte, 2001). Because cortisol rapidly diffuses into saliva, salivary cortisol concentrations reliably mirror changes in cortisol concentrations in blood plasma (Peeters et al., 2011).

The most immediate stress response is an increase in adrenomedullary and sympathetic nervous activity, leading to a release of epinephrine and rise in heart rate (HR). In addition, heart rate variability (HRV; short-term fluctuations in HR) is an indicator for the response of the autonomic nervous system to stress and reflects the oscillatory antagonistic influence of the sympathetic and parasympathetic branch of the autonomous nervous system on the sinus node of the heart (von Borell et al., 2007).

Equestrian sports are unique in the sense that they demand the cooperative effort of two non-related species, horses and humans. Positive interaction of the horse and its rider when coping with the emotional and physical challenges of equestrian tasks is a prerequisite for success in sportive competitions. Whereas information exists on the cardiovascular and endocrine response of horses to equestrian training (Dybdal et al., 1980; Cayado et al., 2006; Schmidt et al., 2010a; Becker-Birck et al., in press-a, in press-b), less is known about the response of the rider (Westerling, 1983; Trowbridge et al., 1995; Devienne and Guezennec, 2000). The combined response of the horse-rider team is not well understood.

In a preliminary study, it was found that anticipating a horse's response to a novel object was associated with increased heart rate in the person riding a horse as well as in the animal itself (Keeling et al., 2009). The response of riders to equestrian challenges is not only determined by the physical demands themselves but also by the state of anxiety that may differ between training and competition or performances. Horses respond with an increase in heart rate

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to novel stimuli (Christensen et al., 2006) or situations such as transport (Schmidt et al., 2010b,c), or when mounted for the first time by a rider (Schmidt et al., 2010a). This response decreases with repeated exposure to the same challenge (Schmidt et al., 2010a,b,c). To the best of our knowledge there have been no reports to date examining the extent to which horses perceive the presence of spectators as a challenge at equestrian performances.

In this study, we have analysed HR, HRV and cortisol release as physiological stress parameters in horses and their riders during a public equestrian performance and during a rehearsal that differed from the public performance only by the absence of spectators. We hypothesised that the presence of spectators and the performance atmosphere are perceived by the horses and their riders as a stressful challenge and that the responses of both are closely correlated.

Materials and methods

Horses and riders

For the study, sport horses ($n = 6$) of the French National School for Equitation (ENE), Saumur, were available. The mean age of the horses was 9.7 ± 2.3 years (±SD, 8–11 years) and all were geldings and of the French Sport Horse breed. The animals were kept in individual boxes on straw and fed concentrates three times daily with hay twice daily. Water was available at all times. Horses were exercised on a near-daily basis, (i.e. 5–6 times per week) and were trained for dressage at advanced level including the schools (airs) above the ground.

All riders participating in the study ($n = 6$) were male and members of the classical dressage team of the ENE (Cadre noir de Saumur) and were qualified as professional riders at the highest level of equestrian sports in France. The mean age of the riders was 38.3 ± 4.6 years (±SD, 30–42 years).

All horses were familiar with their rider and vice versa and the pair had been training together for at least 6 months before the study. Both the horses and riders were also well acquainted with the indoor riding arena used for the performance and rehearsal, the warm up arena, the equestrian tasks required, and the presence of spectators.

Experimental design

Horses and riders were studied during a riding performance of the schools (airs) above the ground at the ENE and during a rehearsal for such performances. The airs above the ground or school jumps are a series of higher-level classical dressage movements in which the horse leaves the ground.[1] In this study, they included the *courbette*, the *croupade* and the *capriole*. Horses with the riders mounted were warmed up for between 30 and 40 min before the performance or rehearsal but the warm-up period was excluded from our analysis.

The performances and rehearsals followed an exact and identical choreography and were ridden simultaneously by a group of eight horse-rider pairs. Each performance lasted 7 min and consisted of being ridden in canter and included the airs above the ground (18 jumps). One rider refused to participate in the study and one horse was changed between the rehearsal and performance. Only complete horse-rider pairs were included and thus the number of horses and riders analysed was $n = 6$ each per performance and rehearsal, respectively.

A total of 2–4 horses and riders per session were included in the study and so two performances and rehearsals each were used. The time between experiments was 2 days with four horses and four riders tested in the rehearsal first and the performance thereafter, and the other two horses and riders in the opposite order.

The performances and rehearsals were ridden in the same indoor riding arena and at the same time of the day (including warm up between 10:30 and 12:00 h) and differed only by the presence and absence of spectators (1200 people).

Cortisol analysis

Saliva for determination of basal cortisol concentrations was taken from horses at 30 and 15 min and from riders at 30 min before the riders mounted their horses. Further samples from both horses and riders were taken immediately after each performance and rehearsal, respectively, at Time 0 and at 15, 30 and 60 min thereafter.

In the horses, saliva was collected as described by Schmidt et al. (2010c) with cotton rolls (Salivette, Sarstedt) placed loosely onto the tongue of the horse for 1 min with the help of a surgical arterial clamp until the swab was well soaked. Riders placed the Salivette into their own mouth and gently chewed to stimulate salivation for 1 min. The Salivettes were then centrifuged for 10 min at 1000 *g* and saliva was aspirated and frozen at −20 °C until cortisol analysis.

[1] See: www.cadrenoir.co.uk/the-airs-above-the-ground.

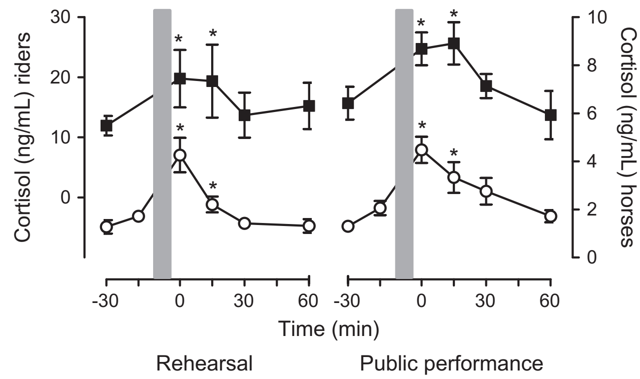

Fig. 1. Cortisol concentration in saliva of horses (○; $n = 6$) and riders (■; $n = 6$) before and after a non-public rehearsal and a public performance of classical dressage. Shaded bars indicate time of rehearsal and performance, respectively. *Values differ significantly from baseline with at least $P < 0.05$. Data are means ± SEM.

Concentrations of cortisol were determined by enzyme immunoassay without extraction (Palme and Möstl, 1997; Schmidt et al., 2009). Since the antiserum cross-reacts with cortisone and some cortisone metabolites, values were interpreted as cortisol immunoreactivity. The intra-assay coefficient of variation was 5.0%, the inter-assay variation 6.7% and the minimal detectable concentration 0.3 pg/well.

Heart rate and heart rate variability

The cardiac beat-to-beat (RR) interval was recorded in horses and riders with a mobile recording system (S810i, Polar) set to RR interval. Recordings in horses were performed as described elsewhere (Schmidt et al., 2010a,c). Recordings in riders were made following the manufacturer's recommendations with two electrodes fixed to the chest with an electrode transmitter belt and a recording watch placed on the wrist. Recordings were made for 1 h directly before riding, continuously during riding and for 1 h thereafter in the horses, and for 30 min directly before riding and continuously during riding in the riders. Recordings before riding were made with the riders standing.

From the RR interval, HR and HRV variables, the standard deviation of RR interval (SDRR) and root mean square of successive RR differences (RMSSD) were calculated. HRV was analysed using Kubios HRV software.[2] To remove trend components, data were de-trended and an artefact correction was made as described elsewhere (Tarvainen et al., 2002; Schmidt et al., 2010a,c).

For comparisons of HR and HRV over time, the 7-min performance and rehearsal, respectively, were each divided into 1 min intervals. Baseline values were determined in horses and riders for 1 min intervals starting 10 min and 5 min before the riders mounted. In addition, 1 min interval recordings beginning 5, 10 and 15 min after riding were analysed in the horses, but post-riding recordings were not possible in the riders.

Statistical analysis

Statistical analysis was done with the SPSS statistics package (version 17.0, SPSS). All data were normally distributed (Kolmogorov–Smirnov-test). Changes over time were analysed for horses and riders by ANOVA using a general linear model for repeated measures with type of equestrian activity (performance or rehearsal) as between subject factors and for horses and riders combined with horse-rider pairs as fixed effect. All data given are mean ± SEM. A *P*-value below 0.05 was considered significant.

Results

Cortisol

In response to both the public performance and an identical rehearsal of the airs above the ground, cortisol concentrations increased significantly in horses ($P < 0.001$) and their riders ($P < 0.01$) and were significantly higher than baseline values immediately (Time 0) and 15 min after the equestrian tasks (Fig. 1).

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