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## **Sudden death in sport and riding horses during and immediately after exercise:**

### **A case series**

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## Summary

**Background:** Sudden death affects the health of horses, the safety of riders and the public perception of animal welfare during equestrian events.

**Objectives:** To describe the signalment, clinical history, sudden death episode, rider injuries and causes of sudden death during exercise or closely thereafter in sport and pleasure riding horses.

**Study design:** Retrospective case series based on an online questionnaire.

**Methods:** An online questionnaire was distributed to the veterinary and equestrian community. Connections of animals reported in the press to have died suddenly were sent the survey. Responses were analysed to obtain information.

**Results:** Fifty-seven cases met inclusion criteria with enough information to be analysed. The most common discipline was eventing (n = 23, 40.4%) and the most common breed involved was Thoroughbred (n = 23, 40.4%). Forty-one (71.9%) horses collapsed during exercise, and 16 (28.1%) shortly thereafter. Twenty-four (42.1%) horses died during or near the time of competition and 33 (57.9%) during or near the time of training or a pleasure ride. In 16 (28.1%) horses the cause of death was known or strongly suspected based on a post mortem result and a cardiovascular origin was reported in 13 of these 16 cases. Riders were injured in 13 (22.8%) cases, and injuries to their extremities were the most frequent.

**Main limitations:** There is potential for misdiagnosis and recall and selection bias and, in the absence of data on the total number of horses engaged in equestrian sports and riding, prevalence cannot be calculated.

**Conclusions:** Sudden death occurred in many types of equestrian sports and in riding horses. Death outside competition was more common suggesting that registries based on reports from official veterinarians underestimate the magnitude of this problem. Rider injuries were not uncommon when ridden horses collapsed and died. A definitive diagnosis for the cause of death was not commonly achieved and cardiovascular origin was the most common where a diagnosis was proposed by survey respondents.

## **Introduction**

Sudden death has been defined as an acute collapse and death of an apparently healthy horse that occurs within minutes of the onset of signs of disease [1]. Horses with catastrophic orthopaedic injuries or trauma are often excluded from the definition of equine sudden death [2]. Causes of sudden death in horses are numerous and include cardiovascular, gastrointestinal, central nervous system disease, haemorrhage or drug reactions.

Literature pertaining to sudden death in horses is scarce and most studies are on racehorses [2-8]. The prevalence of sudden death in racehorses in the UK between 2000 and 2007 was 28.7 sudden deaths/100,000 race starts [2] and the prevalence of sudden death in eventing during competitions sanctioned by the FEI (Fédération Equestre Internationale) between 2008-2014 was 14 sudden deaths/100,000 starts [9]. Information regarding sudden death associated with exercise in sport or riding horses is scarce and there are no formally organised published national or international registries that have been used to describe and evaluate the prevalence and risk factors of sudden death in sport horses.

Sudden death in horses is a rare event with a high emotional and economic component that has severe consequences for horses' health, riders' safety and the public perception of welfare during equestrian sports. More information and awareness about sudden death could help clinicians, officials, and equestrian event organisers decrease the risk or occurrence of these episodes. The specific goals of this study were to describe: (1) the signalment and athletic use of sport and riding horses that suffered sudden death during or near the time of exercise, (2) the medical history of these horses (3) the sudden death episode and the circumstances surrounding it, (4) rider injuries at the time of sudden death and (5) causes of sudden death.

### **Material and Methods**

A link to online surveys was distributed by veterinary and equestrian associations (or representatives of these associations) of Belgium, Canada, the United Kingdom, France, Germany, Ireland, Spain, Switzerland and the United States. Equestrian magazines and on-line equestrian forums also distributed the survey. The choice of countries was by convenience. Additionally, an internet search was made to find press notes for horses that died suddenly during exercise using standard research tools and searching for keywords such as death, collapse, sudden death, 'passed away' or accident and horse. Riders, or owners and veterinarians associated with the dead horses and for which contacts were available on line, were reached via email and requested to answer the survey. Respondents were given the option to complete the survey anonymously.

Two different surveys were designed to collect information from (1) veterinarians (Supplementary Item 1) and (2) from riders, trainers or owners (Supplementary Item 2). Surveys collected analogous information but the language and structure was modified for each group. Surveys were available in English (Supplementary Items 1 and 2), French, German and Spanish and distributed using an online site (surveymonkey.com). Horses of common riding disciplines were included. These are the FEI (Fédération Equestre Internationale) disciplines eventing, show jumping, dressage, endurance, as well as western performance, show and field hunters, polo and pleasure riding or lesson horses. Racehorses were not included. Our survey design allowed for respondents to include descriptions of both collapse and sudden death cases. Confirmation that death had occurred was achieved by review of the responses to questions 19, 20, 23 and 24 (Supplementary Item 1) and 18, 19, 21, 22 and 24-26 (Supplementary Item 2). Horses were included if death occurred when the horse was being ridden or within an arbitrary period of one hour after riding. Riding competition and non-competition was included. Data were summarised and reported descriptively. Horses in which a catastrophic orthopaedic injury, trauma or fall were suspected or confirmed as the cause of the sudden death were not included. There was no limit for the date of the sudden death.

## **Results**

Fifty-seven cases met the above described inclusion criteria and had sufficient information to be analysed. A total of 108 responses to the questionnaire were obtained and 51 were excluded. Causes for exclusion were: sudden death not associated or within one hour of ridden exercise (n = 35), description of sudden death

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in a racehorse (n = 11), description of a collapse episode not followed by death (n = 2), orthopaedic problem was the cause of death (n = 2), not enough information (n = 1). Four responses were from veterinarians and 53 from owners or trainers.

### **Signalment**

There were responses corresponding to fatal events of 39 (68.4%) geldings, 17 (29.8%) mares and one (1.8%) stallion. The mean  $\pm$  s.d. age was  $14.9 \pm 5$  years. The age was unknown for one horse. There were 23 (40.4%) Thoroughbreds, 11 (19.3%) Warmblood horses, 12 (21.1%) crossed horses, 6 (10.5%) Quarter and Paint horses and 1 (1.8%) (each) Paso Fino, Arabian, Welsh Cob, Andalusian and Welsh Mountain pony. The horses' disciplines and levels reported by the owner were as follows: there were 23 eventers (2 beginner, 5 intermediate, 15 advanced and one not specified); 8 Show jumpers (2 beginner, 4 intermediate and 2 advanced); 5 Dressage horses (one beginner, 2 intermediate and 2 advanced); one Endurance horse (intermediate); 4 Fox Hunters (level not applicable), 4 Polo ponies (advanced), 3 western performance (one cutting, one roping, one team penning) horses (one beginner, one intermediate and one advanced) and 9 pleasure riding horses (classified as beginner level). In summary, there were 15 horses reported to be beginner level horses, 13 intermediate, 24 advanced and 5 in which the level was unknown or not applicable. The performance levels were self-assigned by the questionnaire respondents. Horses were grouped as advanced if the respondent categorised the horse as Professional/International or Advanced amateur/National.

## Health history

Eighteen respondents (31.6%) reported that the horse had previous medical problems and thirty-nine (68.4%) did not. These were musculoskeletal problems in 8 (14.0%) horses, heart murmurs in 3 (5.3%) horses, laryngeal problems and recurrent airway obstruction in 2 (3.5%) horses each, and arrhythmia, Equine Protozoal Myelopathy, collapse episodes interpreted as narcolepsy, colic surgery, episode of extreme weakness, near collapse episodes, unjustified falls and parasitism in one (1.8%) horse each. There were horses with more than one problem reported. The time from the last physical examination to death was less than one day in 3 (5.3%) horses, one day-one week in 5 (8.8%) horses, one week-one month in 4 (7.0%) horses, one month-one year in 23 (40.4%) horses, and not specified in 22 (38.6%) horses. In one gelding the sire was reported to have died due to a ruptured aorta but there were not reports of sudden death in siblings.

In 8 horses (14%) a change in behaviour during the weeks or months before collapsing was noted: 6 (10.5%) were less energetic or quicker to fatigue and 'loss of confidence' or 'stiffness' was reported in one horse each (1.8%). One horse had undergone an electrocardiogram, one an echocardiogram and an exercise test/stress test was reported in four horses.

Eleven (19.3%) horses had been given medications within a week of the fatal episode. Two (3.5%) horses received firocoxib, two (3.5%) horses received omeprazole, and the following medications were received by one horse (each) (1.8%): chondroitin sulfate, sodium hyaluronate, polysulfated glycosaminoglycans, estradiol, phenylbutazone, dexamethasone, and pergolide. One horse had had paravertebral and intraarticular infiltrations and the drug injected was not reported.

## **Sudden death episode**

Forty-one (71.9%) horses collapsed and died during exercise and 16 (28.1%) within an hour of exercise. Twenty-four (42.1%) sudden death episodes were during or within an hour of a competition (or fox hunt). These were: 9 (15.8%) cross country phases during eventing, one (1.8%) stadium jumping phase during eventing, 5 (8.8%) show jumping/show hunting, 2 (3.5%) endurance, one (1.8%) team penning, one (1.8%), roping 3 (5.3%) polo, and one (1.8%) fox hunting and one was not reported. Thirty-three (57.9%) horses died outside of competition in varied circumstances ranging from casual walks during trail rides, warm up period, training at the trot or canter or recovering after riding. Respondents reported the following signs occurring immediately before death: 20 (35.1%) horses became ataxic or disoriented, 16 (28.1%) horses slowed down, became sluggish or stopped. Four (7%) horses spooked, 2 (3.5%) horses became agitated, and 2 (3.5%) whinnied. Each of the following signs were reported in one (1.8%) horse: profuse sweating, backing up, twitching of one ear, bleeding from one nostril, white gums and heavy breathing and tremors/fasciculations, 'became blind' and 'climbing with front limbs'. Twenty-one (36.9%) horses did not show any signs before they fell to the ground. The descriptions of the episode included: rearing and/or falling backwards in 8 (13.8%) cases, losing strength or 'feet giving out' in 8 (13.8%) cases, lying down in a controlled fashion in 8 (13.8%) cases, stumbling and falling in 7 (12.3%) cases, falling sideways in 6 (10.5%) cases and falling forward or 'flat' while galloping in 5 (8.8%) cases.

### **Associated human injuries**

Thirteen (22.8%) people were injured in association with the equine sudden death episode. All injuries occurred to riders and were associated with sudden death episodes during exercise, 31.7% of riders of a horse experiencing sudden death during exercise were injured. Seven people injured their extremities, 5 their head and 2 had thoracic injuries. Two other people had bruises. Injuries to the extremities were described as sprained ankles in 2 cases and in one instance each: dislocated shoulder, dislocated hip, pelvis and femur fracture, 'stretched ligaments in the knee', torn quadriceps, torn muscle and finger injury. The head injuries consisted of concussions in 2 cases, 'loss of consciousness' in one case and trauma to mouth in one case. Thoracic injuries were broken ribs. In one case there was no description of the injury.

### **Diagnosis**

In 31 cases the respondents did not report a post mortem examination being performed. Twenty-six horses underwent post mortem examination but in ten of these cases respondents reported that information was not available.

Information recalled by respondent was available from 14 cases and necropsy reports from 2. The necropsy reports stated myocardial degeneration/fibrosis was the most significant findings in one horse and pericarditis/epicarditis was the most significant finding in the other horse. Respondents reported post mortem examination demonstrated ruptured aorta in 7 horses, and cardiac aneurism and striations in the aorta, congenital heart defect, non-specified cardiac problem, acute heart failure, pulmonary embolism, pulmonary (interstitial) bleeding and lung adhesions in one

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case each were the potential causes of death. In three horses, fractures were detected post mortem and due to the history and appearance pathologists or veterinarians performing post mortem examination determined that this were consequence and not cause of the adverse event.

## **Discussion**

The data obtained in this case series provide information about sport and riding horses that suffered sudden death during or immediately after exercise and the circumstances of the sudden death. The information can be used to support or form hypotheses about the predisposing or risk factors for sudden death. As in previous studies Thoroughbreds were the most common breed and in this study eventing was the most common discipline. The prevalence of sudden death in eventing during competitions sanctioned by the FEI has recently been reported (14 sudden deaths/100,000 starts) [9]. Comparison with the proportions of Thoroughbreds in different sport and pleasure horse populations are not available and the significance of this finding is uncertain. Eventing associations and Eventing riders were specifically targeted when distributing the survey and this could have contributed to selection bias. It is also our impression that equestrian magazines report sudden death in eventing horses more often than in other riding disciplines. The current methodology cannot distinguish whether eventing horses are at a higher risk than other riding horses or our results represent a selection bias. It is possible to speculate that there is higher risk of sudden death in eventing because horses of this discipline are exercising at higher intensity than in most other riding disciplines. This would be supported by the fact that most eventing horses died during or within one hour of the cross country that is the most

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physically demanding phase. In the current population, of 23 eventers in total, 9 died during or within an hour of the cross-country phase, one during the stadium jumping phase and 13 outside of competition. Previous studies have also suggested that injuries, and particularly falls, during the cross-country phase are overrepresented [10-12]. In the current study, in which musculoskeletal injuries, trauma or rotational falls were not included, this was also the case.

Despite the fact that fewer horses compete at advanced levels than at lower levels [13] and pleasure riding, there were more sudden death reported in advanced level horses than in other levels. This suggests that intensity of exercise, or training loads may be a risk factor for sudden death occurrence. Our study design does not allow confirmation of this suggestion. The age of horses in the study we present here was higher than in previous studies about sudden death and this is likely the consequence of the different inclusion criteria and the fact that racehorses were not included in the current study [2, 5].

Eighteen (31.6%) horses were reported to have had previous medical problems. Most of these are common problems in riding horses, perhaps, with the exception of three (5.3%) horses in which a collapse episode, near collapse episode and episode of severe weakness were described. Some of the reported problems, such as cardiac murmurs, upper airway disease, recurrent airway obstruction or arrhythmias, can potentially be associated with sudden death. However, the frequency of these problems in the study group does not seem different than in previously reported asymptomatic groups of horses [14-16]. Medications received within one week of the

time of death by horses that died suddenly in this study were usual medications and there were no medications that were given more commonly than subjectively expected. Most conditions responsible for human sudden cardiac death are clinically silent with only 18% of sudden cardiac death victims having signs prior to the fatal event [17]. The sensitivity of history and physical examination to detect horses at risk of sudden death of cardiovascular causes is unknown but, considering the reported causes of sudden death in horses, it is plausible that it will be low, as is the case in humans [18]. Specificity of physical examination and history findings to predict sudden death is, however, reportedly high in humans [17, 19]. The questions that should be part of routine questionnaires for horse owners and riders and the signs that should alert clinicians about an increased risk of sudden death in horses would require different methodology than the study we propose here. Nevertheless ‘being less energetic than usual’ was the most common recent change reported in this study and three horses had previous episodes of collapse, severe weakness and near collapse. However, our data should be interpreted with caution as recall bias could have affected the results. The heritability of most potential causes of sudden death in horses is not known. Interestingly a stallion that had sired a horse in the study group was reported to have died of a rupture aorta. Unfortunately the cause of death in the horse included in our study remained unknown. A review discussing further comparative aspects between equine and human sudden death has been recently published [20].

Few horses and none of the horses in which a cardiac cause was diagnosed at necropsy had had echocardiograms and resting or exercising electrocardiograms prior to the sudden death episode. The topic of pre-participation screening is controversial in humans and the main disadvantages of universal screenings are the costs of the

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examinations and the unavoidable potential for false positives when screening for a problem with low prevalence. Historical questionnaires, physical examinations and 12-lead ECGs are the most common means to evaluate human athletes during pre-participation screening [21]. The limited information obtained from 12-lead ECGs in horses, when compared to humans, suggests that a potential pre-participation screening program in horses may need a different approach. Echocardiograms, exercising electrocardiograms, upper airway endoscopies (resting or dynamic) or comprehensive exercise tests could be candidates for prospective evaluation. The rare occurrence of sudden death makes the prospective evaluation of pre-participation screening programs a difficult task that would need the collaboration of a large number of veterinarians, riders and equestrian organisations.

The description of events immediately preceding death is consistent with previous reports [22]. Interestingly in 36 (63.2%) cases horses reportedly became ataxic, disoriented or sluggish, slowed down, stopped or refused to move. Whether riders considering these potential prodromal signs of sudden death, and discontinuing exercise or dismounting if these are noticed, would decrease injuries occurrence is uncertain. Some trainers have mentioned to the authors' that in certain disciplines that require frequent and fast decisions, such as eventing, having these type of concerns could potentially be counterproductive for performance or even for safety.

The fact that in 22.8% of all cases and 31.7% of sudden death during exercise there were associated human injuries underscores that equine sudden death relevance goes beyond animal health. These percentages need to be interpreted with caution as are

subject to selection bias, and have the potential to be inaccurate. It has been reported that in 51-59% of cases in which Thoroughbred racehorses fall due to sudden death or catastrophic injury, jockeys are injured [23]. Head injuries were most common in previous reports [24-27], followed by injuries to the extremities, thoracic and lumbar spine [26, 28, 29]. Professional jockeys more frequently injure their limbs, while the frequency of injuries to the head, face and spine [30] is somewhat variable between reports and comparatively more common in amateur riders [26, 27]. Similarly, lesions to the extremities followed by head injuries were the most commonly reported in riders of sport and riding horses in the current study.

Of the 16 (28.1%) cases for which a cause for the sudden death was confirmed, or strongly suspected during necropsy examinations, 13 were cardiovascular in origin and in 3 lung disease was reported. Aortic rupture was the most common specific pathology reported. Previously reported causes of sudden death in horses include cardiac failure, arrhythmias, pulmonary failure, pulmonary haemorrhage, haemorrhage associated blood vessel rupture, and spinal cord injury [2-4]. Cardiac arrhythmias [7] or dynamic upper airway obstructions have been proposed as plausible explanations for the many cases of sudden death in which specific post mortem findings are absent [31]. The data about sudden death causes in the current study have to be interpreted with caution as in most cases (71.9%) the cause of death remained unknown and in many cases surveys were filled in by individuals without medical training. In previous reports the specific cause of sudden death could not be determined in 20-80% of post mortem examinations [2, 4]. Consistent post mortem examinations are frequently not performed in cases of sudden death perhaps due to the difficulty of transporting horses to a necropsy room, the lack of access to

specialised pathologists, financial or emotional reasons. Consistent necropsies and specialised diagnostics in forensic medicine, particularly in cardiac pathology could help increase the knowledge about the causes of sudden death in horses.

The limitations of a case series based on information obtained using a survey include recall, misdiagnosis, and selection bias. The survey was sent to a large number of potential respondents, particularly veterinarians, and this could have introduced self-selection bias. The larger number of responses from riders and trainers may have affected the results and particularly could have caused recall bias. Recall bias could have caused respondents to search their memories for factors which they perceived to be linked to sudden death and in addition the fact that many respondents did not have medical training could have affected the accuracy or completeness of the description of medical details. The specific targeting of event riders may have introduced selection bias. Due to these limitations, the data should be used mainly as hypothesis generating and not used to disregard previous hypotheses.

In conclusion, the current study is novel and relevant to clinicians as collected information of a large group of sports and riding horses having sudden death temporally associated to exercise. Sudden death occurred in many types of sport and riding horses and eventing horses were overrepresented. Reports of horses collapsing and dying during exercise were more common than after exercise. Rider injuries were not uncommon when horses collapsed and died during exercise but fatal injuries or human injuries when sudden death occurred after exercise were not reported. Sudden death outside of competition events was reported more frequently than during

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competition and this suggests that registries based on reports from official veterinarians underestimate the magnitude of the problem of sudden death during sports in horses. A definitive diagnosis for the cause of death was not frequently achieved and cardiovascular origin was the most commonly reported cause. Information obtained in this study could be used to design prospective studies and inform riders about the epidemiology of equine sudden death.

#### **Authors' declaration of interests**

There are no competing interests to declare.

#### **Ethical animal research**

Bern Cantonal Office for Animal Research and Swiss Ethics Committees on research involving humans (Swissethics) have determined that the study could be performed in Switzerland without oversight by an ethical commission. Completion of the questionnaire was taken as participant consent.

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## **Authorship**

C. Navas, F. Althaus and D. Burger contributed to the study design, study execution, data analysis and interpretation, and preparation of the manuscript. N. Basieux contributed to the study design, study execution, and preparation of the manuscript. All authors gave their final approval of the manuscript.

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**Supplementary Information**

**Supplementary Item 1:** Collapse and Sudden Death questionnaire – veterinarian.

**Supplementary Item 2:** Collapse and Sudden Death questionnaire – rider.