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Exercise affects joint injury risk in young Thoroughbreds in training

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ABSTRACT

The aim of this study was to identify exercise-related risk factors for carpal and metacarpo- and metatarso-phalangeal (MCP/MTP) joint injury occurrence in young Thoroughbreds in flat race training. In a 2-year prospective cohort study, daily exercise and joint injury data were collected from horses in 13 training yards in England. Four injury categories were defined: (1) localised to a carpal or MCP/MTP joint based on clinical examination and/or use of diagnostic analgesia with no diagnostic imaging performed; (2) localised to a carpal or MCP/MTP joint with no abnormalities detected on diagnostic images; (3) abnormality of subchondral bone and/or articular margin(s) identified using diagnostic imaging; (4) fracture or fragmentation identified by diagnostic imaging. Multivariable Cox regression analysis was conducted to determine risk factors for injury occurrence, by type (carpal or MCP/MTP) and category. Exercise distances at canter and high speed in different time periods were modelled as continuous time-varying variables.

A total of 647 horses spent 7785 months at risk of joint injury and 184 injuries were recorded. Increasing daily canter distance reduced the risk of Category 1 and Category 3 injuries whereas greater 30-day canter distances increased Category 4 injury risk. More weekly high-speed exercise increased Category 1 injury risk. MCP/MTP injury risk reduced with increasing daily canter distance but increased with accumulation of canter or high-speed exercise since entering training, whereas accumulation of canter exercise was marginally associated with reduced carpal injury risk. Risk of all injury types varied significantly between trainers. The results of this study suggest that regular canter exercise is generally beneficial for joint health, while accumulation of high-speed exercise detrimentally affects MCP/MTP joints.

Introduction

Joint injuries are common in Thoroughbred racehorses in training, contributing up to 15% of days lost from training (Rossdale et al., 1985; Bailey et al., 1999; Dyson et al., 2008). Although epidemiological studies have estimated that around 25–30% of racehorses are affected by joint injuries whilst in training (Bailey et al., 1999; Wilsher et al., 2006; Dyson et al., 2008; Reed et al., 2012), none evaluated exercise-related risk factors for joint injuries unless they involved (fatal) fracture or fragmentation (Hill et al., 2004; Parkin et al., 2005; Anthenill et al., 2007). Field studies investigating risk factors for skeletal injury in Thoroughbred racehorses (reviewed by Parkin (2008)) have suggested repetitive low-impact loading to be detrimental to bone health (Verheyen et al., 2006a,b), whereas high-speed (and thus high-impact) exercise seemed to improve fracture resistance (Parkin et al., 2005; Verheyen et al., 2006a).

In experimental studies in horses, strenuous exercise has been shown to adversely affect cartilage metabolism and composition (Little et al., 1997; Murray et al., 1999, 2000, 2001; Kawcak et al., 2000; Firth et al., 2004; Firth, 2006; Brama et al., 2009), whereas moderate exercise seems to improve cartilage composition and thickness (Palmer et al., 1995; Bird et al., 2000; Brama et al., 2002, 2009; Firth and Rogers, 2005).

In humans, occupational activity that involves repetitive mechanical stress to load-bearing joints has been associated with increased risk of osteoarthritis (OA), in particular knee OA in those whose jobs involve knee bending, kneeling or squatting (Hunter and Eckstein, 2009). Participation in sports that induce repetitive, high-intensity, high-impact and/or torsional loads on joints has been associated with higher joint injury risk, which in turn predisposes to OA in the affected joint later in life (reviewed by Hunter and Eckstein (2009)). Irrespective of previous injury occurrence, elite athletes including long-distance runners, football and tennis players, have also been shown to have higher rates of knee and hip OA in later life compared to non-athletic age-matched controls (Marti et al., 1989; Kujala et al., 1995; Spector et al., 1996). While

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there is no evidence that moderate, low-impact, exercise undertaken by individuals with normal joints increases the risk of developing hip or knee OA, this risk does seem to increase with activity level in recreational sports participants (Hunter and Eckstein, 2009).

The aim of the present study was to identify exercise-related risk factors for carpal and metacarpo- and metatarso-phalangeal (MCP/MTP) joint injuries in Thoroughbred flat racehorses in training. Specific objectives were to quantify the effects of exercise distances accumulated at canter and high-speed per day, 7 days, 14 days, 30 days, 60 days and since entering training on the risk of carpal joint injury, MCP/MTP joint injury and each category of injury. Taking together findings from epidemiological studies in human athletes and experimental studies in horses, we hypothesised that the risk of carpal and MCP/MTP joint injury increases with accumulation of high-speed exercise since entering training.

Materials and methods

Details of the study design, period, trainer recruitment, data collection and case definitions were described in Reed et al. (2012). Briefly, a prospective cohort study was conducted in which yearlings entering commercial race training with 13 trainers in England were monitored for up to 2 years, including the 2007 and 2008 flat racing seasons. Daily exercise records and details of veterinary-diagnosed carpal and MCP/MTP injuries were collected. Cases of carpal and MCP/MTP injury were classified in one of four categories: (1) based on clinical examination and/or use of local analgesia with no diagnostic imaging performed; (2) based on clinical examination and/or use of local analgesia with diagnostic imaging performed but no abnormalities detected; (3) evidence of abnormality of subchondral bone and/or the articular margin using diagnostic imaging (e.g. bone modelling/remodelling, subchondral bone sclerosis, osteophytosis); (4) fracture or fragmentation identified by diagnostic imaging. Multiple reports of injury to the same joint were considered as one injury and classified in the highest category applicable for that injury.

Sample size calculations assumed a continuous increase in joint injury risk with accumulation of high-speed exercise, an incidence rate of 1/100 horse months in horses that performed no high-speed exercise, an average follow-up time of 15 months per horse, 80% power and 95% confidence. Recruitment of 500 yearlings would result in around 7500 horse months of data, which would allow detection of a 0.7% increase in joint injury risk per furlong increase in high-speed exercise.

Exercise data collection

Daily exercise of each horse enrolled in the study was recorded by a designated member of yard staff, including type of exercise, distance when cantering, galloping or racing, and training gallops used. Methods of data recording varied according to the trainer's preference and included a purpose-designed database provided by the Royal Veterinary College (RVC) (eight trainers); trainers' own computerised records (two trainers); MS Excel spreadsheets (two trainers) or handwritten paper records (two trainers). One trainer used the RVC database in year one of data collection but Excel spreadsheets in year two. Exercise data were collected at monthly yard visits, downloaded or entered into Excel format, coded and imported into a custom-designed central MS Access database.

Training records were inspected and suspected inaccuracies or omissions clarified with the person responsible for recording the data. Recorded racing activity was checked against racing records in the *Racing Post* database[1] to ensure accuracy. Custom-designed Access queries were used to check for potential errors, e.g. implausible dates, distances, duplicate records or contradictory entries (e.g. an exercise distance recorded for a horse on box rest). Unexplained reductions in exercise for individual horses were queried with the trainer to clarify the reason for exercise modification.

Statistical analysis

Survival analysis using Cox regression (Cox, 1972) was performed to model the relationship between canter and high-speed exercise distances (in furlongs[2]) and joint injury. High-speed exercise included both galloping at home and racing (exercise at >14 m/s). The dataset contained one daily observation per horse for each day that the horse was enrolled in the study. This allowed canter and high-speed distances to be modelled as time-varying variables, reflecting exercise distances accrued per day, in the previous 7 days, 14 days, 30 days, 60 days and cumulatively since entering training. Varying time periods were chosen to enable evaluation of both short- and long-term exercise patterns in relation to joint injury occurrence. Other exposure variables investigated were Thoroughbred age (in years, as a time-varying variable), gender and trainer. Gender was categorised as female or male (intact males and geldings combined).

Separate models were constructed for each of the different time periods and for each injury category (carpal and MCP/MTP injuries combined in each category), all carpal injuries combined (any category) and all MCP/MTP injuries combined (any category). A horse was considered to become at risk of joint injury on the date it entered the study and ceased to be at risk when it experienced the outcome of interest, was lost to follow-up or the study period ended. Therefore only one injury per horse was included in each analysis.

To investigate the shape of the relationship between continuous variables and joint injury, variables were initially categorised based on quartile cut-off values; then, after visual inspection of plotted coefficients, likelihood ratio tests were performed to test for departure from linear trend. Inclusion of fractional polynomial terms was also considered.

For each model, all exercise variables relating to the relevant time frame and cumulative exercise distances since entering training were considered in multivariable analysis, irrespective of their P value in univariable analysis. Gender, trainer and age were included in multivariable analysis if their P value was $\leqslant$0.30 in univariable analysis. The maximum model was fit and backward elimination used to exclude each variable in turn if it did not contribute to the overall fit of the model by significantly ($P \leqslant 0.05$) reducing its log-likelihood. Where trainer was statistically significant ($P \leqslant 0.05$) as a fixed term in univariable analysis, it was included as a shared frailty term in multivariable analysis. Biologically plausible interactions were tested for in the final models.

All analyses were conducted in Stata 9 (StataCorp) and the level of statistical significance was 5%.

Results

Descriptive results

Detailed descriptive results on joint injury rates, anatomical site and severity of injury were reported in Reed et al. (2012). Briefly, 647 horses contributed 7785 months at risk of joint injury and 184 cases of carpal (n = 82) or MCP/MTP (n = 102) joint injury were recorded in 165 horses (26% of the study population). The overall trainer-adjusted joint injury rate was 1.8/100 horse months (95% confidence interval [CI], 1.2, 2.8). Descriptive statistics of exercise variables are shown in Table 1.

Carpal injury

Of 82 carpal injury cases, two had missing exercise data and three were the second injury diagnosed in the same horse; therefore 77 carpal injuries were included in this analysis. Following multivariable analysis, trainer (P < 0.001) was the only variable significantly associated with carpal injury. Cumulative canter distance was marginally associated with carpal injury after adjusting for trainer, suggesting that increasing cumulative canter distances could be protective of carpal injury (hazard ratio [HR]

Table 1
Mean, median, minimum and maximum distances in furlongs (f) exercised at canter and high-speed in different time periods by a cohort of 647 Thoroughbreds in flat race training in England.

	Time period	Mean	Median	Minimum	Maximum
Canter (f)	1 day	3.9	4	0	28
	7 days	22.6	21	0	124
	14 days	45.0	44	0	224
	30 days	94.7	92	0	467.5
	60 days	182.6	175.5	0	892.5
	Cumulative since entering training	771.5	582	0	6222
High-speed (f)	1 day	0.2	0	0	18
	7 days	1.2	0	0	33
	14 days	2.3	0	0	43
	30 days	4.8	0	0	63
	60 days	8.9	0	0	101
	Cumulative since entering training	29.2	4.5	0	469

[1] See: http://www.racingpost.co.uk.
[2] 1 furlong = 201.168 m.