Right Forelimbs Illustrate Greater Structural Bone Adaptations in Clockwise Racing Thoroughbreds

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Summary

The metacarpophalangeal (MCP) joint is the most commonly injured joint in the forelimbs of racehorses. While several factors contribute to cause these injuries, the magnitude of the stresses that joint tissues experience plays a critical role. For racehorses that consistently race and train in one direction around a track, left and right forelimbs are subjected to unequal loads, potentially leading to different structural adaptations and fracture risk.

The objective of this work was to compare contact stress distributions between MCP joints in the left and right forelimbs of clockwise racing Thoroughbreds. MCP joints from 10 clockwise racing Thoroughbreds were segmented from CT scans. Discrete element analysis was used to determine contact stress distributions at the MCP joint. Right forelimbs experienced lower stresses for the same applied load, suggesting that the right forelimb experiences greater structural adaptations from racing in a clockwise direction.

Introduction

Fractures at the MCP joint are among the most common and fatal injuries experienced by racehorses. There is consensus that these injuries are caused by mechanical fatigue. While several factors contribute to these injuries, the magnitude of the stress that the tissue experiences plays a critical role.

Thoroughbreds race at a gallop, a naturally asymmetrical gait. Additionally, depending on the racing jurisdiction, racehorses will run in either a clockwise or counterclockwise direction around a track. Consequently, for racehorses that consistently race and train in the same direction, their left and right forelimbs are exposed to unequal loading. This may lead to distinct structural bone adaptations and fracture risk.

The objective of this work was to compare contact stress distributions between the left and right forelimbs of clockwise racing Thoroughbreds using discrete element analysis (DEA). We hypothesized that the right forelimb would experience lower stresses for the same applied load, suggesting it undergoes greater structural adaptations due to the higher loading when navigating habitual clockwise turns.

Methods

The MCP joints from 10 Thoroughbred racehorses were segmented from CT scans in Mimics (Materialise, Leuven, Belgium) and exported as stereolithography files for DEA in Matlab. DEA was used to estimate contact stress between the third metacarpal (MC3) and proximal phalanx (P1) and between the MC3 and sesamoids (Ses) throughout the stance phase of gait. An animal-specific, non-uniform cartilage geometry was assumed, and both left and right forelimbs were subjected to the same applied loads [1, 2]. Differences in peak and mean contact stress between the left and right forelimbs were compared using paired t-tests with a criterion $\alpha = 0.05$.

Results and Discussion

Right forelimbs illustrated lower peak stresses at MC3-P1, in support of our hypothesis (Table 1). When racing in a clockwise direction, racehorses navigate the turn with a right lead and often switch to a left lead through the straight. Given that the same loads were applied to both forelimbs in our simulation, these data may suggest that the lead limb (i.e., the right forelimb for clockwise racing) experiences higher loads during the turn when racing in a clockwise direction, leading to greater structural adaptations. Interestingly, existing evidence indicates that the left forelimb of clockwise racing Thoroughbreds is more likely to experience an MCP joint fracture [3], suggesting that the lack of structural adaptations may make it more susceptible to injury.

Conclusions

The MCP joint of Thoroughbred racehorses undergoes asymmetric structural adaptations. These findings suggest that MCP joint fractures may be a direct result of insufficient adaptations to the loading conditions experienced during racing and training. Moving forward, the specific structural features that contribute the most to these contact stress asymmetries will be identified.

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References

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Table 1: Peak and mean (SD) intra-articular contact stresses (p-values comparing left and right forelimbs).

	MC3-P1			MC3-Ses		
	Left Forelimb	Right Forelimb	p-value	Left Forelimb	Right Forelimb	p-value
Peak Stress (MPa)	83.14 (17.03)	68.77 (13.47)	0.02	164.20 (33.15)	166.20 (20.43)	0.87
Mean Stress (MPa)	24.43 (5.55)	22.96 (4.42)	0.51	39.55 (6.18)	36.28 (4.77)	0.27