Does high intensity exercise affect superficial digital flexor tendons?

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Abstract:

Superficial digital flexor tendon (SDFT) injuries are common in equine athletes with up to 11% of athletes sustaining these types of injuries which have limited ability to heal, often ending careers. Tendon injuries take a minimum of 6 months to heal with only a 40% chance of returning to the same level. The eight studies tested different aspects of tendon integrity with different results making a clear relationship impossible to determine. Four of the studies showed that high intensity exercise does degrade the SDFT which could lead to a higher risk of injury while the other four studies found no strong relationship between exercise and tendon degradation.

Key Words:

Tendon degradation, ultrasonographic findings, exercise effects on tendons, tendon management, SDFT

Introduction:

Flexor tendons are an important structure for equine athletes, being one of two load bearing tendons used for movement. SDFT injuries are the most common cause of retirement in equine athletes across all sports. Between 11-30% of flat racehorses are diagnosed with SDFT injuries, 14% of which are career ending (Tamura, et al., 2018). They have a limited ability to heal properly causing reinjury in up to 80% of cases (O'Sullivan, 2007).

In order to limit the extent of these injuries, it needs to be better understood how they occur. Several studies have been done to look at the tendons ultrasonographically, however they often have several variables affecting the tendons which makes it difficult to conclude what the most important factor is (Smith and Cauvin, 2014). There have also been studies conducted using models, however they do not produce an accurate natural condition in which tendon injuries occur. By determining the cause of SDFT injuries, it would allow owners and trainers to modify training in order to improve equine welfare.

Eight studies were reviewed and analyzed to determine the effects of high intensity exercise on SDFTs. Five of the studies were experiments and the other three were correlational. Each tested a different aspect of the tendon and exercise effects. It was hypothesized that high intensity exercise would degrade the SDFT faster, leading to more injuries.

Results:

A number of studies have been conducted on the effects of high intensity exercise on the superficial digital flexor tendon in horses. Table 1 summarizes eight studies reviewed.

Six thoroughbred horses with a mean age of 11 years old to determine the effects of exercise induced hyperthermia on superficial digital flexor tendons (Birch, et. al, 1997). Loose paratenon connective tissue was dissected from deceased horses and then treated in vitro for two weeks. Tendon fibroblasts cultured were subjected to temperatures of 45 degrees C for up to 180 minutes. Cell survival was measured and compared to that of rats kidney fibroblasts and equine dermal fibroblasts. Temperatures experienced in vivo are unlikely to result in tendon cell death.

Twelve 18 month old fillies that had no previous physical training were placed in two groups to determine the effects of exercise on the degeneration of equine superficial digital flexor tendons (Birch, et. al, 2008). Six horses were placed in a group of degenerated tendons and six were in a group deemed to have normal tendons. At the end of the 18 months of exercise, horses were euthanized and the right limb had tissue samples taken to analyze water content, collagen, DNA, and tissue fluorescence while left limbs were mechanically tested until failure. Degenerated tendons are accompanied by changes in the extracellular matrix and exercise suggests accelerating degeneration and aging of the tendon.

An observational study was done with 1,223 thoroughbreds across 14 racing yards in England to track different types of injury and whether they happened during a race or in training (Ely, et. al, 2010). Injuries were tracked across 2 race seasons which is roughly a year and then compared and analyzed. Ex-steeplechase horses were significantly more likely to injure their superficial digital flexor tendon than flat race horses.

Ultrasound imaging was used in a study to track the effects of exercise on foals' superficial digital flexor tendon (Kasashim, et. al, 2002). Fourteen thoroughbred foals were split into two groups at 4 days old. The control group received 4 hours of free pasture time while the exercise group added treadmill exercise to their pasture time. Ultrasound images were taken every 30 days at the beginning of each increase for 14 months. Tendon cell samples were taken post mortem to measure cross sectional area and compare with ultrasound images. The exercise group had a significantly greater increase in cross sectional area.

An eighteen month long experiment containing 33 thoroughbred foals was conducted in New Zealand to understand the effects of exercise on cross sectional areas of the superficial digital flexor tendon (Moffat, 2004). The control group contained 15 horses, 4 colts and 11 fillies, and lived at pasture. The exercise group contained 18 horses, 6 colts and 12 fillies. This group exercised 5 days per week on a 515m grass track as well as living at pasture. Speed and duration increased every 2 weeks. Ultrasonographic images were taken at 5, 8, 12, 15, and 18

months. There was no statistically significant difference in cross sectional areas between the exercise group and the control group.

Injury incidents from 1,571 thoroughbred racehorses were recorded to examine how age, gender, and speed relate to tendon injuries (Perkins, Reid, Morris, 2005). Data was examined over 554,743 study days and then analyzed. Male horses were more likely to injure the superficial digital flexor than female horses. Older horses were also more likely to injure their superficial digital flexor than younger horses. There was no evidence of a relationship between injury and cumulative high speed exercise.

Tenocyte nuclei were counted and classified based on shape and density in a study done to examine the effects of exercise on the superficial digital flexor tendon (Stanley, et. al, 2010). Twelve thoroughbred fillies were used in the study. Six fillies with a mean age of 21 months were placed in an exercise group and six fillies with a mean age of 20 months were part of a control group. The control group walked for the 18 month duration of the study while the exercise group galloped three times a week on an equine treadmill. The fillies were euthanized at the end of the 18 months and samples of their tendons were harvested and analyzed. Type 2 tenocyte density of the superficial digital flexor was significantly higher and the proportion of type 1 tenocyte was lower in the exercise group.

Anthroscopically implanted probes were used in a correlational study to examine the relationship between force and tendon integrity on flat and inclined surfaces (Takahashi, et. al, 2010). Seven thoroughbred horses were used in this study that lasted 4 weeks. Four male and three female horses were used ranging from ages 5 to 8 years old. The right forelimb was used in the first flat exercise experiment and the left forelimb was used in the second incline experiment which took place two weeks after the first experiment. Forces recorded on the SDFT at the trot and canter in the trailing forelimb decreased on an incline compared to flat running at the same speed.

Table 1: Summary of studies reviewed

Author and year	Type of study	Subjects	How they measured the variables	Duration	Experimental conditions	Results
Birch, Wilson, Goodship (1997)	Experimental	6 thoroughbred horses, mean age 11	Loose paratenon connective tissue was dissected and then treated in vitro	2 weeks	Cells were tested under different temperatures reaching up to 52 degrees C.	Temperatures in vivo are unlikely to result in tendon cell death.

Birch, Wilson, Goodship (2008)	Correlational	12 age matched mares	Tissue for the right limb was analyzed for water, DNA, collagen, and tissue fluorescence. Left limb tendons were mechanically tested until failure.	18 months	The degenerated group had 6 horses, the “normal” group had 6 horses.	Specific tendons respond differently to imposed training. Changes suggest accelerated aging of the SDFT as a result of training.
Ely, et. al (2010)	Observational	1,223 thoroughbreds	Tracked injuries from 14 racing yards	2 race seasons (about one year)	N/A	Exsteeplechase horses were significantly more likely to have SDFT injuries on the racecourse than ex-flat horses
Kasashim, et. al (2002)	Experimental	14 thoroughbred foals	Ultrasound imaging of tendons as well as postmortem measurements to validate the cross-sectional areas	14 months	Control group received 4hours pasture exercise and experimental group had the same pasture time and also treadmill workout.	Exercise increased cross sectional area of the tendon.

Moffat (2004)	Experimental	33 thoroughbred foals	Ultrasonographic images were taken of the cross-sectional areas and then analyzed and measured with Scion images. 6 horses from each group were euthanized and the tendon were measured to validate imaging.	18 months	Control group consisted of 15 foals (4 colts, 11 fillies) and were living at pasture. The exercise group consisted of 18 foals (6 colts, 12 fillies) and were exercised five days per week on a 515m grass exercise track. Speed and duration increased as the foals aged.	No statistically significant difference between exercise and control groups.
Perkins, Reid, Morris (2005)	Observational	1,571 thoroughbred racehorses	Injury incidents were reported and documented	554,745 study days	N/A	There was no evidence of relationship between injury and cumulative high speed exercise.
Stanley, et. al (2010)	Experimental	12 thoroughbred fillies	Tenocyte nuclei were counted and classified based on shape	18 months	6 thoroughbred fillies in an exercise group, 6 in a control group that walked	No significant differences were noted between exercise groups and control groups.

Takahashi, et. al (2010)	Correlational	7 thoroughbred horses	Arthroscopically implanted force probes (AIFP) were placed in the leg to measure force on the SDFT	4 weeks	All horses were tested on flat surfaces and incline at the walk, trot, and canter.	Force on the SDFT at trot and canter in the trailing forelimb decreased on an incline compared to flat running at the same speed

Discussion:

It is unclear whether or not superficial digital flexor tendons are significantly degraded by high intensity exercise. Four of the eight studies reviewed showed a positive relationship between high intensity exercise and tendon degradation (Birch, Wilson, Goodship, 2008; Ely, et. al, 2010; Kasashim, et. al, 2002; Takahashi, et. al, 2010). However, four studies did not show a significant relationship between high intensity exercise and tendon degradation (Birch, Wilson, Goodship, 1997; Moffat, 2004; Perkins, Reid, Morris, 2005; Stanley, et. al, 2010). The eight studies tested different aspects of tendon integrity with different results making a clear relationship impossible to determine.

The sample size of horses used in these studies was often too small to produce significant results since many of the studies required euthanasia at the end of the study period in order to dissect and analyze the tendons. Several of these studies also focused on foal tendons which might not be developed enough compared to adult horse tendons to provide significant results.

Future studies should be done to test different types of exercise on the superficial digital flexor tendon like jumping. To avoid euthanasia and increase the subject pool, these studies could be carried out using ultrasound and arthroscopically implanted force probes. Other studies should also be done to test the effects of boots creating heat on horses legs and how that affects the tendon fibers as it was found that the superficial digital flexor tendon degrades at a 45℃. This can be done by using an infrared thermometer to track the temperature of the horse's leg during work with a protective boot or bandage on.

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