INTRODUCTION: Fractures are the leading cause of racehorse fatalities, accounting for 75-80% deaths in North America and Great Britain, and are usually the result of fatigue rather than trauma. More than 60% of fractures in the lower limbs occur in the third metacarpal (MC3) and proximal phalanx (P1) bones, and thus are the focus of this study. Exercise during juvenile growth, when the skeleton is undergoing significant remodeling, may be a means of reducing fracture risk by encouraging bone adaptation. Previous exercise interventions in juvenile horses have reported increased bone area compared to controls, but the analyses were limited to discrete cross-sections. Moreover, it is not clear if the changes in response to exercise resulted in changes in mechanical strength. Therefore, the objectives of this study were to evaluate the effect of an exercise intervention in juvenile horses on (1) MC3 and P1 bone structure and composition along the entire length of the bone and (2) whole bone strength assessed via virtual compression test.

RESULTS: One exercise and two control foals did not complete the study. Challenges with ponying in cohort 1 required foals to be run in hand. There were no significant differences in area fraction or density (total, cortical, or trabecular) between control and exercise groups prior to exercise. There were also no significant differences in changes of bone area fraction, density, or stiffness at 4 weeks post-exercise between control and exercise groups. However, we did observe a potential cohort effect: bone properties in cohort 2 were on average higher than controls but this was not the case for cohort 1. In the P1, there was an additional ~3.5% increase in density at 20 and 80% length in cohort 2 (Fig 1 blue lines) relative to controls (grey line) (Table 1). In contrast, cohort 1 had smaller increases in density and area fraction (Table 1, Fig 1 pink lines). Similar, but less consistent, changes were observed in the MC3. Average stiffness of the MC3 and P1 in cohort 2 was greater than control horses, while average stiffness of cohort 1 horses was below control values.

DISCUSSION: Our observations of cohort level variability in response to exercise may have several origins. Importantly, there were no significant differences in bone properties between the two cohorts at the beginning of exercise. Limitations of animal availability resulted in an unplanned difference of sex: exercise cohort 1 were all female while cohort 2 were males. However, juvenile Thoroughbred horses do not exhibit differences in osteocalcin level based on sex, indicating similar bone turnover rates [3]. Thus, we suspect that the difference in mode of exercise (running in hand vs ponying) between the two cohorts may have had an effect. Running in hand (cohort 1) resulted in an intermittent mode wherein foals were run for approximately 150 m back and forth along a track. Ponying allowed for a continuous bout of exercise with no pauses. Lower levels of bone adaptation to mechanical loading when rest was included in a murine tibial loading model [4] compared to continuous loading has been reported; however, others have reported no differences or opposite trends. These data highlight the sensitivity of bone adaptation to loading regimes.

SIGNIFICANCE/CLINICAL RELEVANCE: This study was the first to quantitatively evaluate the effect of an exercise intervention when young on the structure and density along the entire length of long bones and subsequent effects on strength. Despite sample size limitations, this work provides an important lower threshold that a future exercise intervention should exceed and underscores the importance of exercise mode when designing studies for improved bone health.


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