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Original Article

Effects of racetrack exercise on third metacarpal and carpal bone of New Zealand thoroughbred horses

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Abstract

The response of equine bone to training has not been quantified in racetrack trained horses, only in treadmill exercised horses. Seven two-year-old thoroughbred fillies were trained on sand and grass at a racetrack, in a typical New Zealand flat-race training regime. The horses were exercised 6 days per week for up to 13 weeks. During the day the horses were confined in 4 x 4m sand yards, and were stalled at night. Another 7 fillies of the same age were allowed free exercise in grass yards. The bones of the animals were available after the 13 week experimental period, and were examined using a Siemens Somatom AR CT scanner. To quantify the response of epiphyseal bone, 3mm thick sagittal plane images of the carpus (through the middle of the medial condyle of distal radius) and the distal third metacarpal bone (Mc3) (immediately lateral and medial to the junction of the condyle and the median sagittal ridge) were studied. Appropriate areas of interest were chosen, and the mean tissue density equivalent (Houndsfield Units) was determined. In the carpus, there was a significant effect of exercise in the dorso-distal aspect of the radius ($p<0.01$), dorsal aspect of radial and third carpal bones ($p<0.01$ and $p<0.001$ respectively). In palmaro-distal subchondral bone of Mc3, there was a significant effect on the medial/lateral site ($p<0.01$), which differed between right and left legs, probably due to the effect of the horses having been trained in one direction around the training track. The mean tissue density of the Mc3 epiphysis of the exercised group was 36.8% greater than that of the non-exercised group ($p<0.001$). The study demonstrates that bone response is both rapid and substantial, which should prompt the use of non-invasive diagnostic aids to determine the stage of training in which tissue density changes occur.

Keywords: Training, Exercise, Tissue Density, Carpus, Metacarpal Bone, Horses

Introduction

Understanding the induction of adaptation of bone in racehorses has particular relevance in attempts to reduce the incidence of bone fracture. Training regimens are not well defined, and are frequently designed and altered on a subjective basis by trainers. Little controlled study of bone response has been conducted in the past, and only one has employed racetrack trained horses, to study changes in the proximal sesamoid bone[1], on dirt or woodchip surfaces. Treadmill exercise was used to assess the response of the third metacarpal bone (Mc3) cortex[2] and third carpal bone (C3) cancellous bone[3,4]. In the latter two studies, there was little difference in the increase in bone mineral density in young horses trained for 18 months and 18 weeks respectively.

The present study was designed to determine if a short term training regimen on a grass or sand training track, typical of thoroughbred training in New Zealand, would elicit responses similar to those found earlier on treadmills.

Materials and Methods

Fourteen two-year-old thoroughbred fillies were available. Seven were broken to saddle by a licensed trainer over a period of six weeks. The other seven fillies were confined in pasture pens 25m x 8m, two to a pen (one animal was alone).

The seven exercised horses were housed in stalls overnight, and in small dirt yards during the day. The horses were fed lucerne chaff, oats, commercially formulated pelleted ration (sweet feed), and clover hay; the control (non-exercised) animals were fed 75% of the ration of the exercised horses. All horses were weighed weekly, and

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observed daily for clinical abnormality.

The trained horses were exercised six days a week, in the early morning. The distance and time worked every day were recorded. The exercise regimen consisted of 4 weeks' slow cantering, 4 weeks' fast cantering, followed by 4 weeks' fast cantering with fast gallops superimposed twice weekly.

The left and right Mc3 and left third metatarsal (Mt3) bones were dissected free of skin and flexor and extensor tendons, and sawn transversely at the middle of the bone. The right Mc3 was frozen in a domestic freezer. The left bones, and the whole skinned carpus were preserved in buffered formalin until CT scanning.

The Mc3 and Mt3 bones were scanned in a Siemens Somatom AR scanner. The distal half of both the Mc3 and left Mt3 of each horse were placed in a jig such that the principal longitudinal axis of the shaft of each bone was parallel to the scanning plane, ensuring that the beam passed exactly sagittally through the epiphysis. One 3mm sagittal "slice" was taken from the lateral and medial condyle, the axial border of each slice being at the junction of the median sagittal ridge and the horizontal surface of the condyle. After scanning in the sagittal plane, one 5mm thick transverse section was scanned at a site (T125) 125 mm proximal to the most distal extent of the median sagittal ridge.

The carpus was scanned sagittally. In two horses, the whole carpus was imaged, by taking ten 3mm thick slices, 10mm apart. From these were chosen one scan site for all 14 horses, which was 10mm medial to the line passing through the junction of the radial and intermediate bones and through the ridge separating radial and intermediate facets of the third carpal bone.

In Mc3 and Mt3 epiphysis (E), two regions of interest (ROI) were created. The first (E) included most of the distal epiphysis, and the second (subchondral bone SCB) was a crescent 3-4 mm deep, which extended from the distal to the proximal junction of the flat disto-palmar surface of the epiphysis. The border of both ROI's was positioned approximately 2mm from the visible edge of the boney epiphysis, to abolish edge effects. In the carpus, the ROI's were in cranio-distal radius, caudo-distal radius, dorsal radial carpal bone (Cr), dorsal C3, and dorso-proximal Mc3.

The average density value (in Houndsfield Units-HU) of the ROI's was entered into the MS Access database. Side, site and exercise effects were analysed by ANOVA or t-tests, the level of significance chosen being $p<0.05$.

Results

Most changes were of increased density, which in the Mc3 and Mt3 of exercised horses extended from the disto-palmar aspect across the epiphysis to its dorso-proximal surface, leaving an area of lesser density at the most dorso-distal aspect. In the bones of the carpus, the increased density was evident on scans in the dorsal aspect of the bones.

Mc3/Mt3

Pooled results are shown in Table 1. The E density of the Mc3 epiphysis of the exercised group was 36.8% greater than that of the non-exercised group ($p<0.001$). The SCB density was significantly different between medial and lateral slices ($p=0.0038$) in the right but not the left Mc3. The E density was 5.7% greater in left lateral than in right lateral Mc3 ($p=0.048$). The results were not statistically significant when left and right limb results were pooled. For both the E and SCB density, there was a highly significant ($p=0.0001$) effect of exercise. The cortical bone density at the T125 level was greater in the exercised group than the control group (1622±52 vs 1596±58, $p<0.001$).

Carpus

There were clear differences between the exercise and control group tissue densities in the cranio-distal aspect of the radius ($p<0.01$), dorsal aspect of Cr and C3 bones ($p<0.01$ and $p<0.001$ respectively), but not in the caudo-distal aspect, or in proximal Mc3 (Table 2).

	Medial	**Lateral**	**Significance**
E	821.71±11.72	806.21±11.72	n/s
Subchondral bone	1125.92±12.99	1100.67±12.99	n/s
	Left	Right	
E	824.60±11.72	803.32±11.72	n/s
Subchondral bone	1117.71±12.99	1108.89±12.99	n/s
	Control	Exercise	
E	687.71±11.72	940.21±11.72	P<0.001
Subchondral bone	1042.82±12.99	1183.78±12.99	P<0.001

Table 1. Density (HU, mean±SE) of Mc/Mt subchondral bone and epiphyseal (E) regions of interest.

Discussion

The study demonstrates that bone response is both rapid and substantial. The changes occurred within 13 weeks of the initiation of a conventional training regimen used for young horses in New Zealand. The period was shorter than previously used in other controlled experiments in horses, and it is probable that the track surface was more forgiving than the surfaces used in previous studies, although this has not been measured.

	Control	Exercise	Significance
C3	688.90±110.59	872.88±62.62	P<0.001
Cr	743.78±75.59	938.35±75.59	P<0.01
Mc3	800.60±116.08	843.71±65.00	n/s
R cranio-distal	554.75±49.64	671.48±57.51	P<0.01
R caudo-distal	482.55±43.61	484.51±50.10	n/s

Table 2. Density (HU, mean±SD) in sagittal slice of bones of the carpus. For abbreviations, see text.

The bone response occurred in the dorsal region of the carpal bones, and confirms findings in treadmill trained horses from previous studies[3,4], in one of which[3] the palmar regions of the carpal bones of exercised horses were shown not to have significantly greater bone density. The present study has shown the same finding, of no significant increase in the exercised group, for the caudo-distal aspect of the radius. The increase in density in the dorsal regions is of similar magnitude to previous studies. The lack of significant increase in the dorsal aspect of the proximal Mc3, the most distal bone in the carpus, is probably because in comparison to other ROI's, the dorsal ROI in Mc3 contained more cortical bone, which is known to respond less than cancellous bone.

The density of the whole Mc/Mt epiphysis was greater in the exercised than the control horses. Examination of many scans showed that the increase in density began in the palmaro-distal aspect, which is the site of compressive contact of the condylar surface with the proximal sesamoid bones, and the site of the SCB ROI.

The density of this area was higher than for the whole epiphysis, and accounts for exercise being associated with greater increase of density in the E than in the SCB ROI.

The effect of side on the difference between the lateral and medial slices within a leg was probably due to the effect of the horses having been trained in one direction (counter-clockwise) around the training track.

References

1. Young DR, Nunamaker DM, Markel MD. Quantitative evaluation of the remodelling response of the proximal sesamoid bones to training-related stimuli in thoroughbreds. Am J Vet Res 1991; 52:1350-1356.
2. McCarthy RN, Jeffcott LB. Effects of treadmill exercise on cortical bone in the third metacarpal bone of young horses. Res Vet Sci 1992; 52:28-37.
3. Firth EC, Delahunt J, Wichtel JW, Birch H, Goodship AE. Galloping induces regional functional adaptation within the third and radial carpal bones of thoroughbred horses. Equine Vet J 1999; 31:111-115.
4. Firth EC, Goodship AE, Delahunt J, Smith T. Osteoinductive response in the dorsal aspect of the carpus of young thoroughbreds in training occurs within months. Equine Exercise Physiology 5. Equine Vet J (Suppl) 1999; 30:552-554.