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BONE MINERAL DENSITY CHARACTERISTICS OF THE
THIRD METACARPAL/ METATARSAL DISTAL EPIPHYSIS
OF THOROUGHBRED HORSES

A thesis presented in partial fulfilment of the requirements for the degree of

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New Zealand

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Abstract

This thesis includes two studies using non-invasive imaging techniques to quantify, in detail, the bone mineral density (BMD) characteristics of the distal third metacarpal (Mc3) and metatarsal (Mt3) epiphyses of Thoroughbred horses associated with exercise exposure and condylar fracture. Additionally, the relationship between the bone structure of the distal Mc3/Mt3 epiphysis and incurred cyclic loading, as well as techniques for imaging the area non-invasively, are reviewed.

Mt3 bones from fourteen trained or untrained Thoroughbred horses and Mc3 bones from fourteen Thoroughbred racehorses with or without condylar fracture were scanned using peripheral quantitative computed tomography (pQCT) at a site on the distal epiphysis. The relative proportions of volumetric bone mineral density ($BMD_V$) and the spatial distribution of $BMD_V$ were quantitatively assessed using conventional and ArcGIS software. The relative proportion of voxels within nine threshold categories of $BMD_V$ and spatial statistics of $BMD_V$ distribution were compared for regions of interest in the palmar/plantar epiphysis between respective treatment groups; trained vs. untrained controls or fractured vs. non-fractured controls.

In study one, trained horses had a significantly higher ($P \leq 0.006$) proportion of high $BMD_V$ voxels and a significantly lower ($P \leq 0.006$) relative proportion of low $BMD_V$ voxels than controls in the central condylar regions of the plantar Mt3 epiphysis. In other regions of the plantar epiphysis the trained horses also had a significantly higher ($P \leq 0.006$) relative proportion of high $BMD_V$ voxels than controls; however, there were no significant differences for the relative proportion of low $BMD_V$ voxels. These relationships were also evident with multiple correspondence analysis. There was strong to marked clustering of high $BMD_V$ voxels in the central condylar region of all of
the trained horses ($I = 0.64 - 1.0, P = 0.01$) and no clustering of low BMD$_V$ voxels. In contrast, half of the control horses had clustering of high BMD$_V$ voxels, which was weak to strong ($I = 0.64 - 1.0, P = 0.01$) and there was weak to moderate clustering of low BMD$_V$ voxels in the lateral and medial central condylar regions ($I = 0.45-0.62, P = 0.01$ and $I = 0.45-0.57, P = 0.01$, respectively).

In study two, there were no significant differences between the median age ($P = 0.7$), number of race starts ($P = 0.5$), the relative proportion of BMD$_V$ voxels, or the spatial distribution of BMD$_V$ voxels in regions of the palmar Mc3 epiphysis between the fractured and control groups.

The results of this thesis suggest that the response of bone to exercise is specific in relation to anatomical site, the thresholds of BMD that change, and the spatial distribution of BMD. In both studies the exercise exposure was responsible for much of the variation in the relative proportions and the spatial distributions of BMD$_V$.

The clinical relevance of these findings are that detailed quantification of previous exercise exposure needs to be considered when determining if a BMD response of the Mt3/Mc3 epiphysis is part of a physiological or pathological finding.
Acknowledgements

There have been three people who have continuously believed that I would complete this thesis in the short time frame that I had. Even when the pressure was increased because of freezer malfunctions, a successful surgical residency application and a wedding, my supervisors were there for me. I sincerely thank Dr Chris Rogers, Dr Erica Gee and Dr Wendi Roe who are my most supportive mentors, role models and advocates. I will always remember the time, energy and commitment you have given to help me complete this thesis and tackle other milestones in the last six months.

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This study would not have been possible without the support of the New Zealand Racing Board, who funded it through the Equine Partnership for Excellence. Thank you; it has been a privilege to be able to contribute to the understanding of catastrophic injury.

Thank you to my family, who organised the other aspects in my life while I was engulfed in academia. Last but not least, immense thanks to my new husband Dan; in the last six months you have heard more than is healthy about horse bones, been my groom, maid of honour, cook and counsellor. You have harnessed a highly strung filly and I am excited about where we will end up in this race.
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<td>BMD</td>
<td>Bone mineral density</td>
</tr>
<tr>
<td>BMDV</td>
<td>Volumetric bone mineral density</td>
</tr>
<tr>
<td>CT</td>
<td>Computed tomography</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic information systems</td>
</tr>
<tr>
<td>Mc3</td>
<td>Third metacarpal bone</td>
</tr>
<tr>
<td>MCA</td>
<td>Multiple correspondence analysis</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>MSI</td>
<td>Musculoskeletal injury</td>
</tr>
<tr>
<td>Mt3</td>
<td>Third metatarsal bone</td>
</tr>
<tr>
<td>POD</td>
<td>Palmar/plantar osteochondral disease</td>
</tr>
<tr>
<td>pQCT</td>
<td>Peripheral quantitative computed tomography</td>
</tr>
<tr>
<td>PSBs</td>
<td>Proximal sesamoid bones</td>
</tr>
<tr>
<td>ROI</td>
<td>Region of interest</td>
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<td>SCB</td>
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