Morphometric analysis of acetabular rim shape among ancient Mongolian pastoralists

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Introduction

The adoption of nomadic pastoralism may have marked new physiological stresses to the hip for the bipedally-adapted human rider. Relatively few studies have examined differences in acetabular shape resulting from long-term equestrianism [1, 2]. Steppe populations of Mongolia began a nomadic pastoral lifestyle during the Late Bronze Age, which has persisted to the present day, with whole communities of men, women, and children riding horses as part of their lifestyle.

Materials and Methods

Three-dimensional laser scans captured morphometric data of os coxae of pastoral samples (n=34) from the National University of Mongolia. Samples date from four periods, spanning incipient pastoralism in the Bronze Age to the later Mongol Period (Table 1, Figure 1). To determine whether acetabular shape among pastoralists is distinct, these pastoral data are also compared to scans of 20th century “White” Euro-American samples from the Hamann-Todd human (HTH) osteological collection (n=20).

Scan Data Analysis

CloudCompare (v.2.3), an open source 3D point cloud processing software, was used to: 1) trim points—as close as possible within the same plane—to the acetabular rim (Figure 3); and 2) obtain radius distance of this rim. These data were analyzed for the shape of the acetabular rim relative to a best fitted cylinder. A least-square algorithm using the Gaussian-Newton method fits a cylinder against the 3D data points along the rim. The Gaussian-Newton method estimates the parameters of a cylinder through minimizing the sum of squares of the Euclidean distances from input points to the cylinder surface. As these Euclidean distances are along the radius of the cylinder, they are known as “radial distances.” The magnitude of these radial distances is an indicator of the deviation of the rim from a perfect cylinder.

Results

Within the Mongolian sample there are no significant differences between subadults and adults in acetabular rim shape, nor between males and females (both adolescent and adult comparisons) (Table 2).

Table 2. Results of t-tests comparing normalized radial distances STD (mm)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mongolian</td>
<td>0.214</td>
<td>0.833</td>
<td>-0.951</td>
<td>20</td>
<td>0.353</td>
</tr>
<tr>
<td>HTH</td>
<td>0.030</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Despite the differences in their form of subsistence-related movements, there are also no significant differences between the HTH sample with the Mongolian pastoral sample (comparison by age and sex). A one-way ANOVA test of Mongolian adult samples to those of HTH, while showing no significant difference between sites, suggests the Scythian sample is significantly different from Xiongnu and Mongol period samples, and close to the level of significance in difference with the HTH sample (Table 3).

Discussion and Conclusion

These results suggest the acetabular rim shape does not change significantly as a result of long-term horse riding. Within the Mongolian samples there are no significant differences among men, women, and subadults, but historical accounts note the young starting age of riding among Mongolians of both sexes [3, 4], which may explain these results. The Scythian sample may be distinct from the other periods (and HTH) since they were a western nomadic group that may have had a different riding style, and possibly different genetic heritage and associated hip morphology. What is surprising is the lack of distinct differences between the Mongolian samples and the 20th century HTH collection, which comprise different genetic and activity profiles.

Possible explanations: 1) (Mongolian style of) horse riding does not markedly alter hip shape, which must still conform to bipedal locomotion; 2) limitations of small sample sizes; and/or 3) analysis may need to account for shape metrics other than radial distance as a measure of distortion, e.g., total acetabular (concave) shape, not just rim. Future studies can address these questions.

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