Comparison of Three Techniques for the Quantification of Hindfoot Alignment

Samantha McGlone B.Ed., Gabby Rabadam, Veronica Young, Gurtej Grewal, Ph.D., Bijan Najafi PhD, Daniel Latt, M.D.,Ph.D

Human Movement Biomechanics Laboratory, iCAMP, University of Arizona
Comparison of Three Techniques for the Quantification of Hindfoot Alignment

Samantha McGlone B.Ed
Gabby Rabadam
Veronica Young
Gurtej Grewal, Ph.D,
Bijan Najafi PhD
Daniel Latt, M.D., Ph.D

Disclosures are in the Final AOFAS Mobile App.
We have no potential conflicts with this presentation.
Evaluation of the changes in coronal plane alignment of the hindfoot during the single leg heel rise test (SLHR) and the Coleman block test (CBT) play an important role in treatment decision-making for flatfoot and cavus foot disorders.

Estimation by a trained observer is often sufficient for clinical purposes, but more quantitative measures are needed in the research setting.

There are a number of devices that can be used to quantify change in angle, but there is no data to help choose among them.
The goal of this study was to compare the accuracy and repeatability of three techniques (goniometer, digital video analysis (Video), and inertial measurement sensor (IMS)) for the quantification of hindfoot alignment during CBT and SLHR.
• The change in hindfoot alignment during SLHR and CBT was measured in 31 subjects using a goniometer, Video, and IMS.

• Hindfoot alignment was defined as the angular deviation between the calf midline axis and the calcaneus longitudinal axis.

• Subjects performed each test three times on each foot. Hindfoot alignment was measured at initial (resting) and final positions using each of the three techniques.
• Lin’s concordance correlation coefficient (LCCC) was used to calculate reproducibility between the IMS and the other two measurement systems. Values of ±1 denote perfect concordance and discordance, while values of 0 denote absence of concordance.

• Results were plotted on a Bland-Altman plots for a visual representation of the reproducibility of results between systems. 95% limits of agreement were computed for each comparison.
Figure 1: The measured changes in hindfoot angle for each subject were averaged over the 3 trials. Lin’s Concordance Correlation Coefficient was used to calculate concordance between the IMS and the other two measurement systems.

<table>
<thead>
<tr>
<th></th>
<th>Video CBT</th>
<th>Video HR</th>
<th>Goniometer CBT</th>
<th>Goniometer HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordance Correlation</td>
<td>0.5731</td>
<td>0.4713</td>
<td>0.3307</td>
<td>0.1387</td>
</tr>
<tr>
<td>Lower two-sided 95% CL for pc</td>
<td>0.4008</td>
<td>0.2211</td>
<td>0.1624</td>
<td>-0.021</td>
</tr>
<tr>
<td>Upper two-sided 95% CL for pc</td>
<td>0.7062</td>
<td>0.6632</td>
<td>0.4786</td>
<td>0.2921</td>
</tr>
</tbody>
</table>
RESULTS

Figure 2: Bland Altman (BA) plot comparing the goniometer measurement to the IMS in the Coleman block test.

Figure 3: BA plot comparing the goniometer measurement to the IMS in the single leg heel raise test.
Figure 4: BA plot comparing Video to IMS in the Coleman block test

Figure 5: BA plot comparing Video to IMS in the single leg heel raise test
• The average angle change measured was significantly greater for the video and IMS than the goniometer indicating that the goniometer may underestimate the magnitude of change.

• Correlation coefficients (LCCC) for the video and the goniometer measurements when compared with IMS were both well below the accepted standard of >0.90 required to demonstrate strong concordance.

• These results show poor strength-of-agreement and low reliability amongst the various methods of measurement of hindfoot angles.
• The major limitation of this project is the lack of a gold standard measure of hindfoot alignment that would allow for evaluation of the accuracy of each of the measurement techniques.

• Further research will include evaluating the accuracy of each of the measurements by comparison with hindfoot angles obtained from a Vicon motion capture system, which has demonstrated a high degree of accuracy for biomechanical measurements in previous studies.


McClusky W, Lovell W, Cummings R. The Cavovarus Foot Deformity - Etiology and Management. *Clinical Orthopaedics and Related Research*

Windolf M, Götzen N, Morlock M. Systematic accuracy and precision analysis of video motion capturing systems—exemplified on the Vicon 460 system. *J Biomechanics Vol12(5); 2776–2780*


