THE RELATIONSHIP BETWEEN ANKLE MOVEMENT AND THE SURFACE ANATOMY OF THE JOINT

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INTRODUCTION

A line connecting the tips of the lateral and medial malleoli is commonly used as an approximation to the axis of dorsi-/plantarflexion at the ankle joint complex (Zatsiorsky, 1998). This convention is recommended by Cappozzo et al (1995) and Wu et al (2002) when constructing a Joint Coordinate System (Grood & Suntay, 1983) for the ankle. The work described here was undertaken as a preliminary investigation of the validity of the above assumption when measuring unloaded motion at the ankle joint complex in vivo, using surface markers.

METHODS

Subjects were seated on a treatment couch with their shanks hanging freely. Two rigid-body collections of three retro-reflective markers were used to track the movement. One set was attached to the shank over the tibial plateau, and the other was attached to the foot. The collections of markers were attached to the right limb using wide elasticated straps. A third set of markers was configured as a digitising pointer. The markers were tracked using a Polaris system from Northern Digital Inc.; data was collected using bespoke software written in Agilent VeePro.

The tips of the lateral and medial malleoli were palpated and digitised. Subjects were asked to alternately dorsiflex and plantarflex their foot to comfortable limits. They were instructed to minimise the movement of the toes. Five dorsi-/plantarflexion cycles were recorded, and the subject then relaxed. This was repeated three times. The markers were then removed completely, before they were reattached and the entire procedure was repeated.

Helical axis parameters were calculated for a single rotation between the maxima and minima of each cycle. The angle between the direction vectors of the measured axis and the intermalleolar line was calculated as the arccosine of their dot product. Analysis of the data was performed using Matlab.

RESULTS AND DISCUSSION

Sample results from three subjects are presented in Table 1. For each subject, all three series were recorded in a single session. The first and most obvious point to note is that in all cases, the angle between the direction vectors is non-zero. This indicates that, under these measurement conditions, the dorsi-/plantarflexion axis cannot be assumed to be coincident with the intermalleolar line.

While there is considerable variation between subjects, for a given subject the results show a high degree of consistency. For Subjects 2 and 3 the agreement would be even better if the measurements from Cycle 1 were ignored; this could be justified as the range of motion (noted in brackets) is markedly smaller than for the other Cycles. This observation in itself may indicate that the axis changes over the range of movement.

SUMMARY

The results indicate that, for unloaded rotations, the axis of dorsiplantarflexion deviates from the intermalleolar line to a varying extent according to the individual. This should be taken into account when describing such motion.

REFERENCES


ACKNOWLEDGEMENTS

The authors acknowledge the help of Graham Petley with analysis of the data and thank Christoph Reinschmidt for his Matlab routine used to calculate the helical axis parameters.

Table 1: Sample results from three series of five dorsi-/plantarflexion cycles for three subjects. The results presented are angles between direction vectors representing the helical axis and the intermalleolar line, with the range of the rotation from which the axis was calculated in brackets; both are in degrees.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Series 1</th>
<th>Series 2</th>
<th>Series 3</th>
<th>Series 1</th>
<th>Series 2</th>
<th>Series 3</th>
<th>Series 1</th>
<th>Series 2</th>
<th>Series 3</th>
<th>Series 1</th>
<th>Series 2</th>
<th>Series 3</th>
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<tbody>
<tr>
<td>Cycle 1</td>
<td>70.1 (54.4)</td>
<td>70.6 (52.7)</td>
<td>71.5 (54.6)</td>
<td>49.5 (44.0)</td>
<td>53.9 (43.1)</td>
<td>50.5 (41.6)</td>
<td>17.8 (60.1)</td>
<td>20.7 (52.6)</td>
<td>24.0 (54.2)</td>
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</tr>
<tr>
<td>Cycle 2</td>
<td>71.8 (64.8)</td>
<td>71.3 (59.1)</td>
<td>71.3 (58.3)</td>
<td>56.5 (58.8)</td>
<td>55.6 (64.0)</td>
<td>56.7 (63.1)</td>
<td>28.4 (77.0)</td>
<td>28.3 (70.2)</td>
<td>30.8 (69.5)</td>
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<tr>
<td>Cycle 3</td>
<td>72.4 (62.1)</td>
<td>71.3 (55.4)</td>
<td>71.4 (59.2)</td>
<td>57.5 (61.6)</td>
<td>55.7 (61.8)</td>
<td>56.9 (63.3)</td>
<td>25.6 (79.7)</td>
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<td>Cycle 4</td>
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<td>71.6 (58.0)</td>
<td>71.8 (58.4)</td>
<td>58.2 (62.1)</td>
<td>59.6 (64.6)</td>
<td>58.5 (62.4)</td>
<td>27.1 (72.9)</td>
<td>27.7 (70.0)</td>
<td>30.6 (69.1)</td>
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<tr>
<td>Cycle 5</td>
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<td>72.0 (62.9)</td>
<td>70.8 (58.6)</td>
<td>58.7 (62.4)</td>
<td>56.8 (61.6)</td>
<td>57.0 (60.9)</td>
<td>27.0 (75.6)</td>
<td>26.4 (70.3)</td>
<td>29.7 (66.1)</td>
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<td>Average</td>
<td>71.3 (60.5)</td>
<td>71.4 (57.6)</td>
<td>71.4 (57.8)</td>
<td>56.1 (57.8)</td>
<td>56.3 (59.0)</td>
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<td>25.9 (66.2)</td>
<td>28.9 (65.5)</td>
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