Measurements of normal joint angles by goniometry in calves

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Keywords
Calf, joint angle, range-of-motion, goniometry

Summary
Objective: The aim of this study was to establish normal reference values of the forelimb and hindlimb joint angles in normal Holstein calves.

Methods: Thirty clinically normal Holstein calves that were free of any detectable musculoskeletal abnormalities were included in the study. A standard transparent plastic goniometer was used to measure maximum flexion, maximum extension, and range-of-motion of the shoulder, elbow, carpal, hip, stifle, and tarsal joints. The goniometric measurements were done on awake calves that were positioned in lateral recumbency. The goniometric values were measured and recorded by two independent investigators.

Results: As a result of the study it was concluded that goniometric values obtained from awake calves in lateral recumbency were found to be highly consistent and accurate between investigators (p <0.05).

Clinical significance: The data of this study acquired objective and useful information on the normal forelimb and hindlimb joint angles in normal Holstein calves. Further studies can be done to predict detailed goniometric values from different diseases and compare them.

Material and methods
Animals
Thirty Holstein calves (15 males and 15 females) were included in this study. The 30 calves were randomly selected from a local farm for inclusion in the study. The criteria for inclusion in the study were that calves ≤45 days of age, had no signs of lameness, and had normal results on examination of the musculoskeletal system.

Goniometric method
A standard transparent plastic goniometer was used to measure the passive maximum flexion, maximum extension, and range-of-motion of the shoulder, elbow, carpal, hip, stifle, and tarsal joints based on previously described methodology (2). One forelimb and the ipsilateral hindlimb were evaluated on each calf. Goniometric measurements were done on awake calves because of genetic selection (12). Because of these reasons Holstein breed calves were specially selected as the study material.

In calves, abnormal range-of-motion values may be related to a specific joint, tendon or musculoskeletal disease such as arthritis, tendinitis, flexural deformity or angular limb deformity. It is valuable to predict the diagnosis, prognosis, severity, and outcomes of these aforementioned disorders, both for welfare and economic reasons. It is thought that these normal values could add some valuable data in these kinds of clinical problems. The aim of this study was to evaluate the repeatability of goniometric measurements made by two independent investigators, and report reference values for normal joint motion in clinically and orthopaedically normal Holstein calves.
that were positioned in lateral recumbency by two independent investigators (ÖŞŞ, MTÇ) for each animal. The complete range-of-motion was used to determine the axis of each joint before taking the goniometric measurements, as previously described for dogs (5). Joints were flexed and extended to estimate the centre-of-rotation. The goniometer was then placed, and aligned with the bone shafts as defined in the next paragraph, with its centre over the point of rotation.

Carpal flexion and extension range-of-motion values were determined as the angles formed by the long axis of third...
metacarpal bone and the line joining the cranial to caudal midpoint of the antebrachium at the level of the ulnar styloid process and the lateral humeral epicondyle. Elbow flexion and extension range-of-motion values were defined as the angles formed by the line joining the cranial to caudal midpoint of the antebrachium at the level of the ulnar styloid process and the lateral humeral epicondyle, and a line joining the lateral epicondyle and the greater trochanter of the femur and greater trochanter and a line joining the lateral humeral epicondyle to the point of insertion of the infraspinatus muscle and the spine of the scapula (▶ Figure 1).

Tarsal flexion and extension values were determined by placing the arms of the goniometer aligned with the longitudinal axis of third metatarsal bone and the tibial shaft, respectively. Flexion and extension values of the stifle joints were measured as the angles formed by the long axis of the tibial shaft and the stifle joints were measured as the angles formed by the line joining the lateral femoral epicondyle and the greater trochanter. Hip joint flexion and extension values were determined as the angles formed by the line joining the lateral femoral epicondyle of the femur and greater trocanter and a line joining the sacral tuberosity of the ilium and the ischial tuberosity (▶ Figure 2).

Statistical analysis

Statistical analyses were performed by use of computer software. Descriptive statistics (mean ± standard deviation) were calculated for all goniometric data to evaluate inter-tester variability. The median measurements for the two investigators were compared by use of paired t-tests for each joint position. Mean, standard deviation, p-value, median, and 95% confidence intervals (CI) of the mean for combined measurements made by each investigator were calculated. For all comparisons, differences were considered significant at values of p < 0.05. An intra-class correlation coefficient was used to determine the reliability of the measurements performed by the two different investigators (inter-tester reliability). The closer the value was to 1, the more repeatable the result.

Results

The goniometric measurement values obtained by each investigator, and the mean, standard deviation, p-values, 95% confidence intervals, and median angle values for each joint position in the healthy Holstein calves are given in ▶ Table 1. Agreement statistics of the goniometric measurements at maximum flexion and maximum extension are given in ▶ Table 2. Results of measurements made by the two investigators did not differ significantly.

According to the coefficient of variation of the flexion data obtained from both of the investigators, it was found that the most reliable values were the hip joint, and the least reliable values were the tarsal joint values. Extension values were more reliable than flexion values. The maximum repeatability of flexion was found in the hip joint and the least in the tarsal joint values. The maximum repeatability of extension was found in the tarsal joint values

<table>
<thead>
<tr>
<th>Joint</th>
<th>Position</th>
<th>Mean ± SD</th>
<th>p-value</th>
<th>%95 CI of the mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Investigator 1</td>
<td>Investigator 2</td>
<td></td>
<td>Investigator 1</td>
<td>Investigator 2</td>
</tr>
<tr>
<td>Carpal</td>
<td>Maximum flexion</td>
<td>31.67 ± 3.69</td>
<td>0.204</td>
<td>25–38</td>
<td>20–35</td>
</tr>
<tr>
<td>Elbow</td>
<td>Maximum flexion</td>
<td>41.10 ± 7.22</td>
<td>0.076</td>
<td>30–60</td>
<td>25–55</td>
</tr>
<tr>
<td></td>
<td>Maximum extension</td>
<td>140.90 ± 8.16</td>
<td>0.152</td>
<td>130–155</td>
<td>120–160</td>
</tr>
<tr>
<td>Shoulder</td>
<td>Maximum flexion</td>
<td>50.83 ± 7.44</td>
<td>0.244</td>
<td>35–65</td>
<td>40–72</td>
</tr>
<tr>
<td></td>
<td>Maximum extension</td>
<td>129.47 ± 12.82</td>
<td>0.244</td>
<td>105–150</td>
<td>110–150</td>
</tr>
<tr>
<td>Tarsal</td>
<td>Maximum flexion</td>
<td>37.53 ± 4.75</td>
<td>0.721</td>
<td>30–50</td>
<td>30–60</td>
</tr>
<tr>
<td></td>
<td>Maximum extension</td>
<td>153.67 ± 10.82</td>
<td>0.926</td>
<td>130–170</td>
<td>130–175</td>
</tr>
<tr>
<td>Stifle</td>
<td>Maximum flexion</td>
<td>42.17 ± 7.04</td>
<td>0.742</td>
<td>30–57</td>
<td>30–50</td>
</tr>
<tr>
<td></td>
<td>Maximum extension</td>
<td>139.83 ± 11.66</td>
<td>0.152</td>
<td>115–160</td>
<td>115–160</td>
</tr>
<tr>
<td>Hip</td>
<td>Maximum flexion</td>
<td>59.20 ± 5.90</td>
<td>0.258</td>
<td>40–68</td>
<td>40–70</td>
</tr>
<tr>
<td></td>
<td>Maximum extension</td>
<td>130.33 ± 14.62</td>
<td>0.130</td>
<td>95–150</td>
<td>105–150</td>
</tr>
</tbody>
</table>

Agreement statistics of goniometric measurements at maximum flexion and maximum extension are given in ▶ Table 2. Results of measurements made by the two investigators did not differ significantly.

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Table 2

<table>
<thead>
<tr>
<th>Joint</th>
<th>Maximum flexion coefficient</th>
<th>Maximum extension coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal</td>
<td>0.498</td>
<td>*</td>
</tr>
<tr>
<td>Elbow</td>
<td>0.725</td>
<td>0.838</td>
</tr>
<tr>
<td>Shoulder</td>
<td>0.701</td>
<td>0.818</td>
</tr>
<tr>
<td>Tarsal</td>
<td>0.404</td>
<td>0.925</td>
</tr>
<tr>
<td>Stifle</td>
<td>0.603</td>
<td>0.923</td>
</tr>
<tr>
<td>Hip</td>
<td>0.737</td>
<td>0.905</td>
</tr>
</tbody>
</table>

*This value was not calculated.
while the least repeatability was found with the shoulder joint values. The inter-tester reliability was less repeatable for measurements in flexion.

According to the values obtained from one of the investigators (MTÇ), there was no difference between males and females. However, according to the other investigator, there was a significant difference between male and female calves in range-of-motion values for extension of the elbow joint (males: 138.0 degrees; females: 143.8 degrees).

Discussion

The data from these normal Holstein calves will provide reference values for the forelimb and hindlimb joint angles for calves. Holstein calves were chosen for this study because they are the most common breed in our province.

Previous goniometric studies that assessed inter-observer variability and experience did not reveal any significant differences in goniometric joint measurements (2, 5, 10, 13). In the present study, in which all measurements were performed by two independent investigators with relevant experience, the differences between investigators were generally not significant. Other investigators have implied that goniometry does not have a steep learning curve (5). Some goniometric studies evaluating the effect of sedation in cats and dogs have reported goniometric measurement values that were similar to those in awake animals (1, 5). However, another study had significantly different goniometric measurements obtained among anesthetized and awake horses (13). In the present study, we decided to obtain the goniometric measurements in unsedated animals to get a clinical screening tool. Because the calves were easily handled and restrained, no difference would be expected between awake and sedated measurements. Sensory-limited and mechanically-limited range-of-motion values can be differentiated by comparing unsedated and sedated values. When pain is present during joint manipulation, range-of-motion can be sensory-limited. But under sedation, pain-free maximal range-of-motion can be measured. Further studies using anesthetized calves should be accomplished to compare these values.

Objective goniometric values can be used as a helpful diagnostic, monitoring, and outcome assessment tool. Although the results of this study validated the use of goniometry in normal calves, additional research on frequently encountered calf diseases such as arthritis, and flexural and angular deformities is needed.

Acknowledgments

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Conflict of interest

None declared.

References

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