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Measurements of normal joint angles using goniometer in Malabari goats in Kerala

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Abstract
The present study was designed to provide normal reference values of the forelimb and hindlimb joint angles of Malabari goats having one year of age from University Goat and Sheep Farm, CVAS, Mannuthy, Kerala. The measurements were taken from 30 clinically normal animals without any detectable musculoskeletal abnormalities. A standard goniometer was used to measure the maximum extension, maximum flexion and range of motion of the shoulder, elbow and carpal joints of the forelimb and hip, stifle and hock joints of the hindlimb. The goniometric values were measured by two independent investigators and the values were compared statistically. The values obtained were consistent and no significant difference were obtained between two investigators ($p>0.05$). Goniometer was found to be very effective for measuring the angles. The data obtained is useful as a basic data for the clinicians and surgeons.

Keywords: Malabari Goat, joint angle, extension, flexion, goniometry

1. Introduction
Goniometry is a modest, consistent, non- invasive and low expensive clinical method often used by orthopedic surgeons to assess the severity of joint injuries and to screen clinical development of the patient [1, 3]. Goniometry is inevitable in the inspection of joints and surrounding soft tissue [4]. For several joints such as carpus, tarsus, stifle, elbow, shoulder and hip joints are mainly assessed by goniometry in canine orthopedics, to evaluate joint disease and treatment effectiveness [1, 5, 9]. In feline orthopedics, goniometry is an effective and reproducible method to measure joint range-of-motion and it could actually be used to estimate joint diseases and monitor progression [1, 7]. In the ovine model (Santa Ines sheep), goniometry was found to be useful for orthopedic studies in which the evaluation of range-of-motion were essentially estimated in conditions from osteoarthritis, bone deformities and their correction, prosthesis development for stifle surgery to total joint replacement, and articular ligament reconstruction [2, 10]. In Holstein calves, abnormal range-of-motion values were related to a specific joint, tendon or musculoskeletal disease like arthritis, tendinitis, flexural deformity or angular limb deformity [11]. To our knowledge, goniometry has not been validated in goats. Malabari goats are dual purpose breed mostly reared in Kerala. One of the major orthopedic condition seen in goats' other small ruminants were fracture of long bones. Frightened or tired goats were used to captured by holding the limb leading to serious fractures or dislocations [12]. Main reason for skeletal ailments in goats were due to curiosity and climbing instincts of goats, fracture secondary to struggling, trauma from dog attacks [13]. Because of these reasons Malabari goats were specifically selected for the study. It is valuable both for welfare and economic reasons, to forecast the diagnosis, prognosis, severity and outcomes of these musculoskeletal disorders. Normal values on this area is lacking which can be used as a reference data that help in the diagnosis of clinical conditions affecting joints and bones. The aim of this study was to assess the repeatability of goniometric measurements taken by two independent investigators and account for a reference value sheet for normal joint motion in clinically and orthopedically normal Malabari crossbred goats.

2. Material and Methods
2.1 Animals
Thirty Malabari Goats were included in this study. The goats were randomly selected from University Goat and Sheep Farm, Mannuthy for inclusion in the study.

The criteria for inclusion in the study were that goats were around 1 year of age, had no signs of lameness and had normal results on examination of the musculoskeletal system.

2.2 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 goat. Goniometric measurements were taken on awake goats that were positioned in standing position by two independent investigators (AJ, TJ) 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 center-of-rotation. The goniometer was then placed and aligned with the bone shafts as defined in the next paragraph, with its center 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 to the point of insertion of the infraspinatus muscle on the greater tubercle of the humerus. Shoulder flexion and extension range-of-motion values were determined as the angles formed by the line joining the lateral humeral epicondyle and the point of insertion of the infraspinatus muscle and the spine of the scapula (Fig. 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 line that joined 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 trochanter and a line joining the sacral tuberosity of the ilium and the ischial tuberosity (Fig. 2).

2.3 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 mean measurements for the two investigators were compared by use of paired t-tests for each joint position. Mean, standard deviation, p-value, 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.

3. Results and Discussion

The goniometric measurement values obtained by each investigator with the mean, standard deviation and p-values for each joint in the healthy Malabari crossbred goats are given in Table 1. There was no significant difference between the two investigators (p>0.05). According to the data obtained from both of the investigators, it was found that the most of the measurements were reliable between two investigators. The values obtained were consistent. The data from these normal Malabari goats can be used as a reference values for the forelimb and hindlimb joint angles for goats. Malabari goats were selected for the study due its increased population in Kerala. Previous goniometric researches that evaluated inter-observer variability did not make known any significant variances in goniometric joint measurements [2, 5, 10, 14]. In the current study, the differences between two investigators were mostly not significant in which all measurements were performed by investigators with relevant experience. Other investigators were reported goniometry without steep learning curve [5]. Various other goniometric studies which estimated the effect of sedation in cats and dogs had reported similar goniometric measurement values to that of awake animals [1, 5]. However, another study in horses revealed significant difference between anaesthetized and awake horses in goniometric measurements [14]. In the present study, data were obtained from unsedated animals in standing position to relate the values as a tool in the clinical screening of cases. The expected difference was feeble between awake and sedated measurements, due to the easiness in the handling and restraining of goats. When pain generate during joint manipulation, range-of motion would diminish which is a result of sensory-limitation. Sensory-limited and mechanically-limited range-of-motion values can be distinguished by comparing unsedated and sedated values. But under sedation, the advantage is that pain-free maximal range-of-motion can be measured. Further studies using anesthetized goats are necessary to compare these values. Goniometric values can be used as a helpful diagnostic, monitoring and treatment outcome assessment tool. Although the present values validated the use of goniometry in normal goats, further research on frequently encountered goat diseases such as arthritis, dislocation and angular deformities is required.

Fig 1: Goniometric measurements of forelimb joints: (A) shoulder extension (B) elbow extension (C) knee extension (D) elbow flexion

Fig 2: goniometric measurements of Hindlimb joints: (A) Hip extension, (B) Stifle extension, (C) Hook Extension and (D) Stifle Flexion

Table 1: Mean ± standard deviation (SD and p-values in maximum flexion and maximum extension of the forelimb and hindlimb joints in goats according to two investigators

Joints	Maximum flexion			Maximum Extension		
	Investigator 1	Investigator 2	p value	Investigator 1	Investigator 2	p value
Shoulder	66.83±1.42	65.67±1.38	0.34	98.50±3.72	97.67±4.00	0.31
Elbow	34.17±1.40	34.03±1.32	0.22	122.67±1.58	120.67±1.80	0.63
Knee	27.83±2.14	27.33±1.84	0.65	157.33±1.43	155.33±1.11	0.67
Hip	49.00±3.39	46.67±2.79	0.81	94.17±3.75	95.01±3.65	0.55
Stifle	36.10±2.42	38.67±0.42	0.52	112.5±3.35	111.67±2.89	0.75
Hock	30.33±2.17	32.00±2.85	0.37	141.02±3.52	141.33±4.15	0.64

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