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Concurrent Validity of a Universal Goniometer and a Double Meter Inclinometer for Passive Range of Motion in Beagle Dogs

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Abstract : The purpose of this study was to evaluate the concurrent validity of the double meter inclinometer (DMI) for passive joint range of motion (ROM) in beagle dogs and to compare these results to a universal plastic goniometer (UPG). Fifteen beagle dogs were recruited for this study. Joint ROM was evaluated twice with each device to calculate the intraobserver reliability. The intraclass correlation coefficient (ICC) values of the UPG were good to excellent (> 0.75) for all joint ROM tests. Similar results were obtained with the DMI. The ICC values of the DMI were good to excellent (> 0.75) except in extension of the tarsal joint (ICC = 0.69). The majority of the ICC results between each device were poor (< 0.50) with the exception of six joints. Our findings suggest that the inclinometer can be used for passive joint ROM in veterinary medicine. However, caution should be taken when comparing measured values of passive joint ROM obtained utilizing both the DMI and UPG.

***Key words* :** range of motion, inclinometer, goniometer, intraobserver reliability, dog.

Introduction

The evaluation of passive joint ROM is a fundamental process to assess the injury and prognosis of a joint in a clinical setting. The universal plastic goniometer (UPG) is mostly used to measure passive joint ROM in veterinary medicine (13). The UPG was reported to possess good reliability in dogs and cats. However, these reports mainly evaluated flexion and extension of passive joint ROM, while other ROMs such as abduction, adduction, internal rotation, and external rotation were not evaluated for their reliability (1,2).

In human medicine, multiple tools are available to measure passive joint ROM (5,6). Of these, the goniometer and inclinometer are universally utilized. The goniometer has advantages of simple use and low cost. However, a limitation of the UPG is that both hands need to be used simultaneously for the test and it is difficult to locate anatomical landmarks. These limitations increase the risk of error due to inaccurate measurement and incorrect placement (6,8). UPG has been found to have good intrarobserver reliability (ICC > 0.80), but interobserver reliability (ICC < 0.50) is poor (8,11). The inclinometer uses the gravity constant as a reference point and has been adopted as a popular method for the measurement of ROM in human medicine. It has been shown to have good intraobserver (ICC > 0.80) and interobserver reliability (ICC > 0.80) (4). However, to the best of our knowledge, while a previous study has assessed the validity of the electrogoniometer compared with the UPG in veterinary medicine (9), the validity of the inclinometer has not been evaluated.

The purpose of this study was to evaluate the concurrent validity of the double meter inclinometer (DMI) for passive joint ROM in beagle dogs and to compare these results to those obtained with the UPG.

Materials and Methods

Animals

Fifteen beagle dogs (10 intact males and 5 intact females; mean age 3.6 ± 0.7 years and mean weight 13.6 ± 2.16 kg) were recruited for this study. All dogs underwent physical and radiographic examination to ensure the absence of orthopedic diseases. The care and use of the animals reported in this study were approved by the Institutional Animal Care and Use Committee of Chonbuk National University.

Instruments

The UPG (IMEX Veterinary, Inc., Longview, TX, USA) was a standard 18 cm by 4 cm device with 2° increments and a 360° scale (Fig 1A). The DMI (Petrometer® systems, Kirkland, WA, USA) had two needles, one being a magnetic directional needle for horizontal measurements and the other a gravitational inclinometer needle for vertical measurements. The rotational-degree ring on the inclinometer was used for the zero position (Fig 1B).

Study design

All procedures were conducted in a single session by one investigator. The left forelimb and the ipsilateral hindlimb were assessed on each dog. The flexion and extension evalu-

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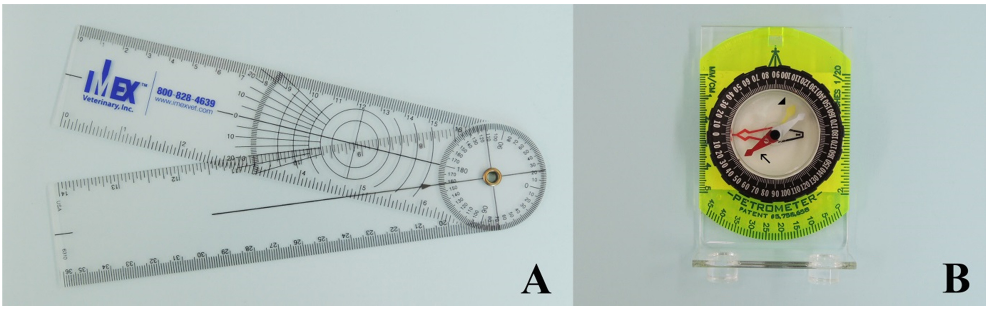

Fig 1. A) Goniometer; B) Double Meter Inclinometer (Petrometer®), transometer needle (arrow), inclinometer needle (arrow head).

ations were each performed 3 times in the shoulder, elbow, carpal, hip, stifle, and tarsal joints. The other ROM positions were evaluated according to the particular joint. Abduction, adduction, internal, and external rotation were also measured in the shoulder and hip joints. Pronation and supination were also measured in the elbow joint, ulnar and radial deviation in the carpal joint and version and inversion in the tarsal joint. All of these joint ROMs were obtained twice with each device to calculate the intrarobserver reliability. The joint ROM protocol was based on the veterinary orthopedic textbook (7). The joints were positioned perpendicularly and neutral to determine a starting point. All ROMs were measured in degrees from the zero starting point. The center of rotation of the goniometer was placed over the center of motion at each joint. Then joint ROM was read using each arm of the goniometer (7). The DMI was placed over the center of motion too. The rotational-degree ring was turned to line up with 0º degrees with the red needle for horizontal measurements and the yellow needle for vertical measurements. Then measurements were read from each needle.

Statistical analysis

All joint ROM data were expressed as mean ± standard deviation (SD). An unpaired Student's t-test was used to compare the data of the UPG and DMI. The reliability of all joint ROM data was determined by the intraclass correlation coefficient (ICC) for intraobserver reliability. The intraobserver reliability was also calculated to correlate the results between each device. Portney and Watkins criteria were used to interpret ICC agreement values: good to excellent (> 0.75), moderate to good (0.50-0.75), or poor (< 0.50) correlations. ICC agreement values (model 2.3) and 95% CIs were calculated using 'scale analysis' with a two-way random effect model and 'absolute agreement'. p values less than 0.05 were considered significant. All statistical analyses were performed using SPSS (SPSS, IBM Corporation, Chicago, USA) version 18.0.

Table 1. Reliability results of the goniometer and the inclinometer for passive range of motion of the shoulder joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	P values	ICC[b] (95% CI)
Flexion	62.6 ± 8.9	0.92 (0.7-0.97)	70 ± 7.4	0.95 (0.86-0.98)	0.001	0.33 (−0.19-0.65)
Extension	52.1 ± 9.1	0.80 (0.43-0.93)	59.3 ± 12.2	0.92 (0.59-0.98)	0.013	0.64 (0.14-0.84)
Abduction	44.4 ± 15.2	0.91 (0.76-0.97)	39.3 ± 7.3	0.91 (0.72-0.97)	0.117	0.84 (0.56-0.93)
Adduction	29.5 ± 7.3	0.75 (0.3-0.91)	34.7 ± 5.2	0.82 (0.00-0.95)	0.003	0.41 (−0.12-0.70)
Internal rotation	43.1 ± 3.6	0.79 (0.36-0.93)	46.3 ± 3.6	0.81 (0.45-0.93)	0.005	0.42 (−0.09-0.71)
External rotation	27.8 ± 6.4	0.95 (0.85-0.98)	39.6 ± 9.9	0.96 (0.90-0.98)	0.000	0.37 (−0.22-0.75)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Table 2. Reliability results of the goniometer and the inclinometer for passive range of motion of the elbow joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	P values	ICC[b] (95% CI)
Flexion	83.5 ± 12.8	0.95 (0.87-0.98)	81.3 ± 8.8	0.85 (0.54-0.95)	0.443	0.48 (−0.08-0.75)
Extension	47.5 ± 2.8	0.90 (0.72-0.96)	38.2 ± 34	0.79 (0.39-0.93)	0.000	0.00 (0.00-0.02)
Pronation	42.5 ± 6.4	0.87 (0.62-0.95)	40.6 ± 3.5	0.94 (0.77-0.98)	0.161	0.00 (0.00-0.2)
Supination	48.9 ± 10.5	0.92 (0.78-0.97)	45 ± 13	0.87 (0.62-0.95)	0.212	0.89 (0.71-0.95)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Results

The reliability of all ROM measurements of the shoulder, elbow, carpal, hip, stifle and tarsal joints expressed as mean ± SD, ICC (95% CI), and P values are provided in Tables 1, 2, 3, 4, 5, and 6.

The ICC values of the UPG were good to excellent (> 0.75) for all joint ROM tests, from adduction of the shoulder joint (ICC = 0.75) to extension of the carpal and hip joint (ICC = 0.96). The average UPG ICC was 0.87. Similar results were obtained from the DMI. The ICC values of the DMI were good to excellent (> 0.75) from extension of the elbow joint and eversion of the tarsal joint (ICC = 0.79) to extension of the carpal and hip joint (ICC = 0.98), with the exception of extension of the tarsal joint (ICC = 0.69). The average DMI ICC was 0.88.

The majority of ICC results between each device were poor (< 0.50) except for abduction of the shoulder joint (ICC = 0.84), supination of the elbow joint (ICC = 0.89), extension of the carpal (ICC = 0.93), hip (ICC = 0.93), and stifle joints (ICC = 0.80) and inversion of the tarsal joint (ICC = 0.91).

Table 3. Reliability results of the goniometer and the inclinometer for passive range of motion of the carpal joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	*P* values	ICC[b] (95% CI)
Flexion	132.6 ± 14.6	0.90 (0.70-0.96)	138.5 ± 3.5	0.81 (0.46-0.93)	0.041	0.16 (−0.56-0.58)
Extension	24.9 ± 10.2	0.96 (0.90-0.98)	25 ± 7.4	0.98 (0.96-0.99)	0.977	0.93 (0.85-0.96)
Ulnar deviation	21.6 ± 4.36	0.79 (0.40-0.93)	25.7 ± 5	0.93 (0.81-0.97)	0.001	0.52 (−0.78-0.76)
Radial deviation	14 ± 5	0.86 (0.59-0.95)	20.7 ± 4.6	0.86 (0.62-0.95)	0.000	0.48 (−0.22-0.73)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Table 4. Reliability results of the goniometer and the inclinometer for passive range of motion of the hip joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	*P* values	ICC[b] (95% CI)
Flexion	132.6 ± 14.6	0.90 (0.70-0.96)	138.5 ± 3.5	0.81 (0.46-0.93)	0.041	0.16 (0.00-0.58)
Extension	24.9 ± 10.2	0.96 (0.90-0.98)	25 ± 7.4	0.98 (0.96-0.99)	0.977	0.93 (0.85-0.96)
Ulnar deviation	21.6 ± 4.36	0.79 (0.40-0.93)	25.7 ± 5	0.93 (0.81-0.97)	0.001	0.52 (0.00-0.76)
Radial deviation	14 ± 5	0.86 (0.59-0.95)	20.7 ± 4.6	0.86 (0.62-0.95)	0.000	0.48 (0.00-0.73)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Table 5. Reliability results of the goniometer and the inclinometer for passive range of motion of the stifle joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	*P* values	ICC[b] (95% CI)
Flexion	82.4 ± 5.1	0.95 (0.87-0.98)	78 ± 4.8	0.90 (0.71-0.96)	0.001	0.49 (0.00-0.76)
Extension	56.2 ± 5.8	0.89 (0.69-0.96)	54.8 ± 5.8	0.97 (0.93-0.99)	0.344	0.80 (0.58-0.90)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Table 6. Reliability results of the goniometer and the inclinometer for passive range of motion of the tarsal joint

	Goniometer		Inclinometer			
Joint motion	Mean ± SD	ICC[a] (95% CI)	Mean ± SD	ICC[a] (95% CI)	*P* values	ICC[b] (95% CI)
Flexion	42.8 ± 3.2	0.93 (0.81-0.97)	34.1 ± 11.6	0.95 (0.85-0.98)	0.000	0.00 (0.00-0.39)
Extension	57 ± 13.3	0.92 (0.77-0.97)	49.4 ± 8.4	0.69 (0.15-0.89)	0.011	0.65 (0.13-0.85)
Eversion	15 ± 2.8	0.77 (0.31-0.92)	14.2 ± 3.3	0.79 (0.37-0.93)	0.292	0.56 (0.10-0.79)
Inversion	18 ± 6.9	0.87 (0.63-0.95)	20.7 ± 7.2	0.95 (0.86-0.98)	0.137	0.91 (0.55-0.97)

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; a: intraobserver reliability, comparison between the first and second measurements; b: intraobserver reliability, comparison between each device.

Discussion

Our study verified the ICC of the DMI and UPG for passive joint ROM in beagle dogs. The results showed good to excellent (average ICC: 0.87) ICC agreement values in the intraobserver reliability of UPG. The results of a previous study are similar to our reliability study in terms of UPG measurements in passive joint ROM. Jaegger *et al*. found good reliability of UPG in Labrador Retrievers (2). Although, our study did not assess the interobserver reliability of UPG, Jaegger *et al*. revealed no significant differences in measurements made by 3 independent investigators (2). However, human studies of UPG for passive joint ROM have demonstrated poor interobserver reliability (< 0.50) (4,11). Most studies, including the present study, have revealed good intraobserver reliability of UPG for passive joint ROM (1,2,4,11). Although, few veterinary medicine studies have shown good interobserver reliability of UPG (1,2), the interobserver reliability of passive joint ROM using UPG requires special attention to its interpretation because many human studies have demonstrated conflicting results.

Our study showed good to excellent (average ICC: 0.88) ICC agreement values in the intraobserver reliability of DMI, with the exception of extension of the tarsal joint (ICC = 0.69). To the best of our knowledge, reliability of the inclinometer for passive joint ROM in veterinary medicine has not been demonstrated. In human medicine, the inclinometer is widely used in clinical practice because it is easy to use, inexpensive, accurate, and can be used to perform repeated measurements (4,10,11). Furthermore, previous studies showed good to excellent interobserver and intraobserver reliability (ICC > 0.80) with the inclinometer (3,10,12). Although our study was limited in that it did not assess the interobserver reliability of DMI, the inclinometer was chosen to measure passive joint ROM given its ease of use, low demand of clinical skill, and excellent reliability in veterinary medicine.

Our study demonstrated statistically poor correlations (ICC < 0.50) in the intraobserver reliability between the DMI and the UPG except for six joint ROMs. A previous study in veterinary medicine did not verify the ICC for passive joint ROM between the DMI and the UPG. Thomas *et al*. compared measurements obtained between a UPG and an electrogoniometer and from radiographs in order to compare joint motion in dogs (9). This study demonstrated that the electrogoniometer had higher variability compared to the UPG for all dogs and recommended against the use of the electrogoniometer in clinical practice (9). We also recommended that the DMI and UPG not be used interchangeably to compare the ROM of a particular joint because our study showed poor correlations of the intraobserver reliability between DMI and UPG in almost all joints.

We found good to excellent ICC agreement values for the intraobserver reliability of the DMI and UPG for passive joint ROM in all measured joints. However, our study demonstrated poor ICC agreement values for the intraobserver reliability between the DMI and UPG. The inclinometer can be used for passive joint ROM in veterinary medicine. Our finding suggests that a cation need to be utilized when comparing measured values of passive joint ROM obtained by the DMI and UPG.

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