Evaluation of femoral inclination angle in the diagnosis of developmental hip dysplasia in Aksaray Malaklı breed dogs

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Abstract
This study aimed to determine the femoral inclination angle parameters of the proximal femur and acetabulum in both healthy and hip dysplasia-affected Aksaray Malaklı dogs. This data contributes to understanding the breed's hip morphology and supports treatment planning for hip dysplasia. The study included 15 Aksaray Malaklı dogs (9 females, 6 males), radiographed in a ventrodorsal (V/D) view at 4, 8, and 12 months of age. Hip dysplasia susceptibility was evaluated using the Fédération Cynologique Internationale (FCI) scoring system, and femoral inclination angles were measured. According to FCI scoring, hip dysplasia was detected in 6.6% of dogs at 4 months, 26.6% at 8 months, and 66.6% at 12 months. A progressive increase in femoral inclination angles was also observed: 26.6% at 4 months, 33.3% at 8 months, and 40% at 12 months. After analyzing the femoral inclination indices for left and right hip joints, statistical results showed no significant difference ($p>0.05$) between sides. It was emphasized that the femoral inclination angle alone is not a sufficient parameter to assess hip dysplasia, as it may lead to misleading conclusions. Although positive statistical changes were observed, an increase in the femoral inclination angle cannot always be correlated with the presence or severity of hip dysplasia. Additionally, orthopedic conditions such as femoral torsion, coxa vara, coxa valga, and arthritis may also be present alongside hip dysplasia.

Keywords: *Aksaray Malaklı dog, FCI score, femoral inclination angle, hip dysplasia*

INTRODUCTION

The Aksaray Malaklı breed is one of the shepherd dog breeds found in the Central Anatolia region of Turkey, particularly in Aksaray, Nevşehir, and Şereflikoçhisar. The most distinguishing feature of this breed compared to other Anatolian shepherd dogs is the morphological differences in the head structure and the drooping lips (Atasoy et al., 2011; Avci et al., 2024).

Hip dysplasia is common in large and giant breed dogs and is inherited through a complex polygenic inheritance model; however, the heritability rate is relatively low. Environmental factors, such as the amount of calories consumed during the growth period, significantly affect the phenotypic expression. Initially appearing as joint laxity, the condition results in osteoarthritis due to subluxation and abnormal wear. Selective breeding programs to reduce this condition have shown limited success to date (King, 2017).

The femoral inclination angle is the angle between the collum femoris and the long axis of the femur. In healthy dogs, this angle is approximately 145°. In dogs with hip dysplasia, the femoral inclination angle increases by 30º-35º (Polat, 2021). According to Hauptman, the femoral inclination angle in dogs varies around 146±5° (Sarıerler et al., 2003). It can be concluded that femoral inclination angle alone is not a significant criterion in hip dysplasia. However, this angle always shows significant inter-breed differences that must be considered (Sarıerler et al., 2017).

The femoral inclination angle plays an important role in the transfer of load from the femur to the acetabulum during walking. The average femoral inclination angles reported vary depending on the measurement method. Hauptman et al. (1979) reported that the femoral inclination angle measured from radiographs of dogs with normal hips was 146 ± 4.80° with one method and 129.4 ± 4.90° when compared with another method. Banfield et al. (1996) reported the average value for normal dogs as 133.48 ± 4.690°. An increase in the inclination angle in hip dysplasia cases has been reported (Sarıerler, 2004), and some studies (Henrikson, 1980; Montavon et al., 1985) show that age and osteoarthritis affect this angle. On the other hand, Hauptman et al. (1979) reported that there was minimal difference in the inclination angle between dysplastic and non-dysplastic dogs and that the hip angle does not play a role in the development of hip dysplasia.

This study aims to determine the inclination angle parameters in 4, 8, and 12-month-old Aksaray Malaklı dogs during their developmental period. These data will provide information about the breed's hip morphology and contribute to treatment planning, especially for hip dysplasia. The inclination angle, which can assist in early diagnosis, will help prevent the use of animals with observed hip dysplasia as breeding stock and facilitate the eradication of the disease.

MATERIALS AND METHODS

The study material consisted of 15 Aksaray Malaklı dogs, including 9 females and 6 males, all at the developmental stage and raised as breeding stock. No distinction was made between gender and weight in the dogs. In the presented study, radiographic examinations of the cases at 4, 8, and 12 months of age were performed, and the standard ventro-dorsal (V/D) radiographs were taken

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to determine the hip dysplasia sensitivity of the Aksaray Malaklı breed using the Fédération Cynologique Internationale (FCI) scoring system. The scoring was performed using a five-level grading system, with ratings from A to E; A indicated normal hips, while E indicated the presence of severe hip dysplasia (Arıcan, 2020) (Table 1).

For the presented project, ethical approval was obtained from the Ethical Committee of the Animal Research and Production Center of the Faculty of Veterinary Medicine, Selçuk University (SÜVDAMEK) and the study commenced after receiving the approval report (dated 24.02.2022, with meeting number 2022/03 and decision number 2022/19). Informed consent forms were obtained from all animal owners, and the animals were included in the study.

Femoral inclination angle evaluation

The femoral inclination angles were determined using the Symax method. According to this method, the inclination angle was defined by drawing three circles touching the cortex at least at two points in the caput femoris, intertrochanteric, and condylar regions. The centers of these circles were then connected to form the inclination angle.

Statistical analysis

In our study, the number of 15 cases was determined by power analysis. This analysis was calculated assuming a minimum sample size of 80% statistical power (power=0.80), a type I error rate of 5% (α=0.05), and a medium effect size. As a result of this power analysis, a sample size of 15 animals was suggested. In the study, femoral inclination angle values of the right and left hip joints of the cases were measured in the 4th, 8th, and 12th months, which were the control periods. The normal distribution of the femoral inclination angle data was examined with the Shapiro-Wilk test. In order to evaluate the change in the measurements over time, the comparisons of the right hip joints in the 4th, 8th, and 12th months periods, and the comparisons of the left hip joints in the 4th, 8th, and 12th months periods, and the repeated measurements ANOVA test were applied. The sphericity assumption, which is a prerequisite for ANOVA, was evaluated with Mauchly's test; for the data for which the assumption was not provided, the Greenhouse-Geisser test was used in the "test of within-subject effect" test, which is a part of the ANOVA test. Within-Subject Contrasts and Bonferroni tests were performed as post-hoc tests. The analyses were performed using SPSS software (version 30).

RESULTS

Femoral inclination angle findings

In our study, 150° was accepted as the threshold value for evaluations. According to the Symax method, the average femoral inclination angle for the right hip joint of the Aksaray Malaklı dogs at 4 months of age was determined to be 143.6°. For the left hip joint, the average value was 145.2°. In the 8-month period, the average femoral inclination angle for the right hip joint was found to be 145.9°, while for the left hip joint, it was 147.2°. At the 12-month period, the femoral inclination angle for the right hip joint was 145.8°, and for the left hip joint, the average inclination angle was 149.5°. The femoral inclination angle radiograph of case number 2 is presented in Figure 1.

Table 1. *Schematic Representation of the FCI Scoring System.*

Score	Dysplasia Status
A	No Clinical Signs of Dysplasia The caput femoris and acetabulum are compatible. The craniolateral acetabular rim appears sharp and slightly rounded. The joint space is narrow and equal. The Norberg angle is approximately 105°. In excellent hip joints, the craniolateral rim surrounds the caput femoris slightly more caudolaterally.
B	Near Healthy Joint Structure The caput femoris and acetabulum are slightly incompatible. The Norberg angle is approximately 105° or the caput femoris and acetabulum are compatible, but the Norberg angle is less than 105°.
C	Mild Presence of Hip Dysplasia The caput femoris and acetabulum are inconsistent, and the Norberg angle is approximately 100° or less. The craniolateral acetabular rim begins to flatten. Osteoarthritis signs are present in a mild form, with cranial, caudal, or dorsal acetabular edges or the caput femoris and femoral neck.
D	Moderate Presence of Hip Dysplasia There is a noticeable incompatibility between the caput femoris and acetabulum with subluxation. The Norberg angle is greater than 90°. The craniolateral acetabular rim is flattened and/or osteoarthritic changes are observed.
E	Severe Presence of Hip Dysplasia Dislocation or noticeable subluxation and dysplastic changes are present in the hip joints. The Norberg angle is less than 90°. Significant flattening of the cranial acetabular edge, deformity of the caput femoris (such as mushroom-shaped flattening), or other osteoarthritic signs are noted.

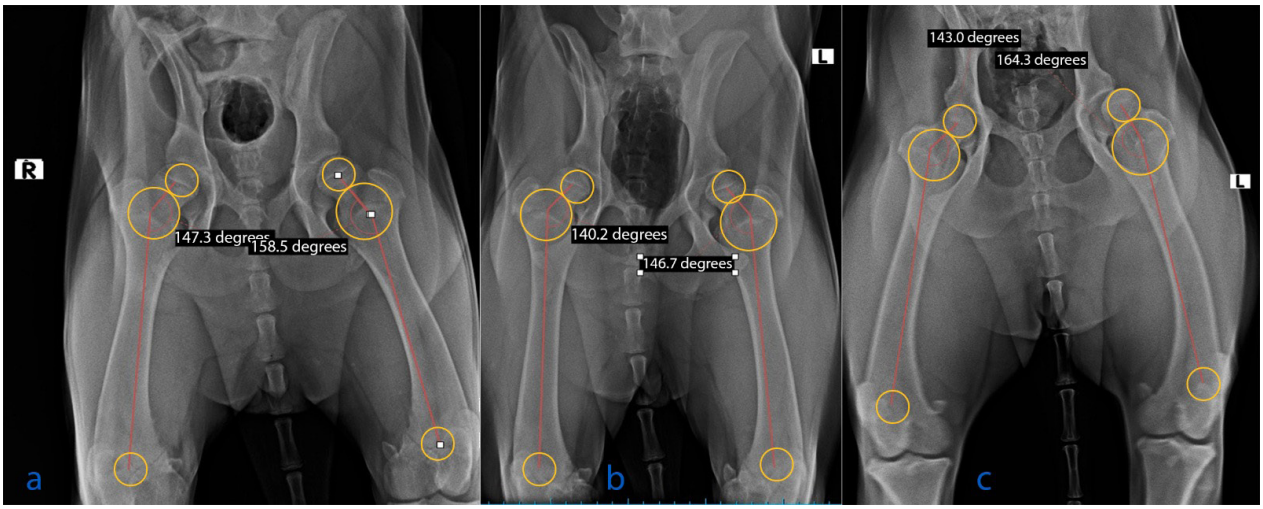


Figure 1. a: *Femoral inclination angle of Case 2 at 4 months of age,* ***b:*** *Femoral inclination angle of Case 2 at 8 months of age,* ***c:*** *Femoral inclination angle of Case 2 at 12 months of age.*

FCI scoring system evaluation findings

According to the FCI scoring system, in the 4-month group, the cases were classified as follows: 11 cases (Case no: 1, 3, 5, 6, 7, 8, 9, 10, 11, 14, 15) in Group A (73.3%), 3 cases (Case no: 2, 12, 13) in Group B (20%), and 1 case (Case no: 4) in Group D (6.6%).

In the 8-month group, 5 cases (Case no: 3, 5, 7, 10, 14) were classified as Group A (33.3%), 6 cases (Case no: 1, 6, 8, 9, 11, 15) in Group B (40%), 3 cases (Case no: 2, 12, 13) in Group C (20%), and 1 case (Case no: 4) in Group E (6.6%).

In the 12-month group, 1 case (Case no: 10) was classified in Group A (6.6%), 4 cases (Case no: 3, 5, 7, 14) in Group B (26.6%), 4 cases (Case no: 1, 8, 9, 12) in Group C (26.6%), 4 cases (Case no: 6, 11, 13, 15) in Group D (26.6%), and 2 cases (Case no: 2, 4) in Group E (13.3%).

The FCI scoring and femoral inclination findings of the 15 cases are presented in Table 2.

According to the FCI scoring system, hip dysplasia was detected at varying degrees in the following percentages: 6.6% in the 4-month group, 26.6% in the 8-month group, and 66.66% in the 12-month group. A significant increase in the evaluated femoral inclination angles was observed: 26.6% in the 4-month group, 33.3% in the 8-month group, and 40% in the 12-month group.

Statistical findings

The normality assumption of the cases was determined to be Shapiro-Wilk test $p>0.05$, and the data showed normal distribution. Then, a one-way ANOVA test was applied for repeated measurements separately for both sides in order to evaluate the change over time. According to this test, Mauchly's Sphericity Test was found as $p>0.05$ ($p=0.48$) in the right hip joint data, and it was determined that the sphericity assumption was met. Accordingly, in the 'within-subject effects' analysis performed without any correction, no significant change was found in the right hip joint over time as $p>0.05$ ($p=0.18$). In the left hip joint data, the sphericity assumption, which is one of the prerequisites of ANOVA, was evaluated with Mauchly's Sphericity Test, and $p<0.05$ ($p=0.01$) was found, and since the sphericity assumption was not met in the left hip joint, Greenhouse-Geisser correction was applied. As a result of the 'Within-subject effects' analysis, no statistically significant change was detected over time, calculated as $p>0.05$ ($p=0.21$).

In the pairwise comparisons made between the time points for both hip joints (4–8th month and 8–12th month), no significant difference was detected ($p>0.05$). In the post hoc Within-Subject Contrast analyses made for the time points between the 4th–8th month and 8th–12th month for both hips, no statistically significant difference was found after Bonferroni correction ($p>0.05$ for all comparisons).

DISCUSSION

Rumph et al. (1990) reported that the most reliable femoral inclination angle determination method in terms of repeatability and reliability in less experienced hands is the Symax method. In a study by Sarıerler et al. (2003), comparing femoral inclination angle measurement techniques in dogs (Hauptman A, Hauptman B, Montavon, and Symax), they stated that Symax is a more reliable and repeatable method compared to the other three methods, especially in less experienced hands. Therefore, in our study, femoral inclination angles were determined using the Symax method.

Hauptman (1983), after evaluating different femoral inclination angle techniques, reported that the normal range of femoral inclination angles is between 130° and 145°. When measurements were taken within this range, it was found that there was no significant difference in femoral inclination angle measurements between dysplastic and non-dysplastic cases.

In the study by Sarıerler (2004) comparing femoral inclination angles between dysplastic and non-dysplastic dogs of different breeds, the femoral inclination angle range for non-dysplastic dogs was found to be 118°–147° for German Shepherds, 123°–145° for Labrador Retrievers, 121°–142° for Pointers, 123°–138° for Irish Setters, 132°–148° for Sivas Kangal, 125°–134° for Doberman Pinschers, and 124°–137° for Golden Retrievers.

In our study, for Aksaray Malaklı dogs, the values for non-dysplastic cases were found to be: 127.2°–158.5° at 4 months, 137.0°–160.1° at 8 months, and 138.0°–

Table 2. *FCI scoring and femoral inclination findings table.*

		4 months				8 months				12 months			
		FCI		Femoral Inclination		FCI Score		Femoral Inclination		FCI Score		Femoral Inclination	
Case	**Gender**	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	Male	A	A	141.4°	155.6°	A	B	142°	160.8°	B	C	141.9°	139.6°
2	Female	A	B	147.3°	158.5°	B	C	140.2°	146.7°	B	E	143°	164.3°
3	Female	A	A	142.9°	137.3°	A	A	147.3°	147.7°	B	A	145°	147.7°
4	Female	D	D	141.1°	142.9°	E	E	142.1°	140°	E	E	153.3°	154.8°
5	Female	A	A	135.9°	153.5°	A	A	137°	137.5°	A	B	138°	139.1°
6	Male	A	A	147.9°	151.8°	B	B	144.2°	160.1°	D	D	143.2°	150°
7	Female	A	A	144.5°	132.3°	A	A	143.7°	142.5°	B	B	144°	143°
8	Male	A	A	144.6°	142.9°	B	B	149.5°	149.2°	B	C	144.2°	160.1°
9	Male	A	A	137.4°	139.6°	A	B	149.8°	154.5°	A	C	147.8°	161.5°
10	Female	A	A	137.1°	127.2°	A	A	141°	147°	A	A	143.2°	150.0°
11	Female	A	A	147.2°	147.0°	A	B	147.7°	142.1°	C	D	143.8°	138.6°
12	Male	B	B	147.7°	147.0°	C	C	141.9°	141.5°	D	C	146.3°	144.1°
13	Female	B	B	155.6°	152.1°	B	B	165.5°	145°	B	B	157.6°	152.1°
14	Male	A	B	145.1°	144.2°	A	B	150.7°	152.2°	B	B	152°	159.5°
15	Female	A	A	147.2°	147.0°	A	B	147.7°	142.1°	C	B	143.8°	138.6°

161.5° at 12 months. These values were found to be higher than those for Sivas Kangal dogs. The higher values were believed to be since Aksaray Malaklı dogs are a giant breed. Sarıerler (2004) stated in his study that there was no significant difference in femoral inclination angles between dysplastic and non-dysplastic animals. This aligns with the findings of other authors, such as Hauptman et al. (1985) and Banfield et al. (1996), who also found no significant difference in femoral inclination angles between dysplastic and non-dysplastic animals. The results of our study parallel these findings.

Most studies conducted on dogs have been limited to investigating whether there is a relationship between hip dysplasia and femoral inclination angles (Sarıerler et al., 2003). In our study, it was found that the angle values in dysplastic cases were relatively higher compared to non-dysplastic cases, but there was no statistically significant increase.

Madsen et al. (1994) in their study were unable to clarify whether the increased femoral inclination angle is a primary cause or a consequence of hip dysplasia. They mentioned that the data obtained from the cases could not be fully assessed for breed specificity. Nevertheless, they noted that an increased femoral inclination angle in dogs without osteoarthritis but with hip dysplasia was noteworthy and suggested that an increased femoral inclination angle might play a primary role in the pathogenesis of hip dysplasia. Vieira et al. (2010) reported that while the increase in inclination angle exacerbates symptoms of degenerative joint disease, it does not play a role in the development of hip dysplasia. The conflicting views in the literature, as well as the findings in our study where hip dysplasia was detected in varying degrees at the following rates—6.6% at 4 months, 26.6% at 8 months, and 66.66% at 12 months, and a significant increase in femoral inclination angles suggest that there is little alignment between these two criteria. This indicates that femoral inclination angle alone is insufficient for evaluating hip dysplasia and may lead to erroneous assessments. However, it is considered that an increase in femoral inclination angle cannot always be associated with hip dysplasia, as other orthopedic issues such as femur torsion, coxae vara, coxae valga, and arthritis can also occur in the absence of dysplasia.

CONCLUSION

In breeds predisposed to hip dysplasia, it is believed that evaluating femoral inclination angles in conjunction with other measurements, such as the distraction index and Norberg angle, provides more objective results. These parameters will facilitate more accurate diagnoses of hip dysplasia and help overcome the limitations of subjective evaluation methods. Future comparative studies that investigate the various aspects of Aksaray Malaklı dogs, research their genetic structure and tendencies, establish proper breed standards from an official perspective, develop breed-specific selection and pedigree breeding models, and focus on the conservation of local genetic resources will be beneficial. More studies on a larger number of cases are recommended for these purposes.

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Conflict of interest

The authors declared no conflict of interest.

Ethical statement or informed consent

This study was approved by the Ethical Committee of the Animal Research and Production Center of the Faculty of Veterinary Medicine, Selçuk University (SÜVDAMEK), and the study commenced after receiving the approval report (dated 24.02.2022, with meeting number 2022/03 and decision number 2022/19).

Author contributions

FGÖ and MA contributed to the project idea and design. FGÖ contributed to the execution of the study. FGÖ and MA contributed to the data collection. MA and FGÖ critically reviewed the manuscript and supervised the study. All authors read and approved the final version of the manuscript.

Availability of data and materials

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Arıcan, M. (2020). Kalça displazisi, tedavi seçenekleri ve kalça protezi. *Kedi ve köpek ortopedi ve travmatoloji* (pp. 229-256). Konya: Anka Promosyon Matbaa Mlz. Ltd. Şti.

Atasoy, F., Erdoğan, M., Yüceer, B., Özarslan, B., Kocakaya, A. (2011). Türk mastifi morfolojik ve genetik özelliklerinin belirlenmesi ve bu köpeğin tanıtılması, *Broşür 1. Baskı,* Medisan Yayınevi Ltd Şti, Ankara, Türkiye.

Avcı, N., Gümüş, F., Boztok Özgermen, B., & Özen, D. (2024). Keratoconjunctivitis sicca in intact Aksaray Malakli breed dogs: Evaluation of 50 cases. *Veterinary Ophthalmology,* In press. https://doi.org/10.1111/vop.13298

Banfield, C.M., Bartels, J.E., Hudson, J. A., Wright, J. C, Hathcock, J. T., & Montgomery, R. D. (1996). A retrospective study of canine hip dysplasia in 116 military working dogs. Part 1: angle measurements and orthopedic foundation for animals (OFA) grading. *Journal American Animal Hospital Association, 32,* 413-422. https://doi.org/10.5326/15473317-32-5-413

Hauptman, J., Prieur, W. D., Butler, H. C., & Guffy, M. M. (1979). The angle of inclination of the canine femoral head and neck. *Veterinary Surgery, 8,* 74–77. https://doi.org/10.1111/j.1532-950X.1979.tb00612.x

Hauptman, J. (1983). Interobserver variation in the measurement of the femoral angle of inclination. *Veterinary Surgery, 12,* 189-191. https://doi.org/10.1111/j.1532-950X.1983.tb00740.x

Hauptman, J., Cardinet III, G. H., Morgan, J. P., Guffy, M., & Wallace, L. J. (1985). Angles of inclination and anteversion in hip dysplasia in the dog. *American Journal of Veterinary Research. 46*(10), 2033-2036. https://doi.org/10.2460/ajvr.1985.46.10.2033

Henriksson, L. (1980). Measurement of femoral neck anteversion and inclination. A radiographic study in children. *Acta Orthopaedica Scandinavica Supplement, 51*(186),1-59. https://doi.org/10.3109/ort.1980.51.suppl-186.01

King, M. D. (2017). Etiopathogenesis of canine hip dysplasia, prevalence, and genetics. *Veterinary Clinics of North America: Small Animal Practice, 47*(4), 753-767. https://doi.org/10.1016/j.cvsm.2017.03.001

Madsen, J. S., & Svalastoga, E. (1994). Inclination and anteversion of *collum femoris* in hip dysplasia and coxarthritis. *Acta Veterinaria Scandinavica, 35*(2), 115–119. https://doi.org/10.1186/bf03548337

Montavon, P.M., Hohn, R.B., Olmstead, M.L., & Rudy, R.L. (1985). Inclination and anteversion angles of the femoral head and neck in the dog evaluation of a standard method of measurement. *Veterinary Surgery,14*, 277-282. https://doi.org/10.1111/j.1532-950X.1985.tb00883.x

Rumph, P., & Hathcock, J. T. (1990). A symmetric axis-based method for measuring the projected femoral angle of inclination in dogs. *Veterinary Surgery, 19*(5), 328-333. https://doi.org/10.1111/j.1532-950X.1990.tb01200.x

Sarıerler, M., & Güzel, N. (2003). Köpeklerde femoral inklinasyon açısının ölçümünde dört farklı yöntemin karşılaştırılması. *Veteriner Cerrahi Dergisi, 9*(3-4), 5-8.

Sarıerler, M., Bozkan Tatlı, Z., Akın, İ., Yaygıngül, R., & Derincegöz, O. Ö. (2017). Radiographic examination of hip joint geometry in healthy Sivas Kangal dogs. *Turkish Journal of Veterinary & Animal Sciences, 41*(1), 85-92. https://doi.org/10.3906/vet-1602-10

Sarıerler, M. (2004). Comparison of femoral inclination angle measurements in dysplastic and nondysplastic dogs of different breeds. *Acta Veterinaria Hungarica 52*(2), 245–252. https://doi.org/10.1556/avet.52.2004.2.13

Polat, E. (2021). Veterinary medicine and a new look at beekeeping. *Iksad Publications*. Pp. 42-75 (63).

Vieira, G. L. T., Tôrres, R. C. S., Barros, G. S., Rezende, C. M. F. (2010). Associação entre o ângulo de Norberg, o percentual de cobertura da cabeça femoral, o índice cortical e ângulo de inclinação em cães com displasia coxofemoral. *Arquivo Brasilerio de Medicina Veterinaria e Zootecnia, 62,* 1094-1101. https://doi.org/10.1590/S0102-09352010000500011