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Temporospatial and kinetic gait analysis in Aksaray Malaklı Shepherd dogs

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Abstract: The present study aimed to determine the gait parameters of Aksaray Malaklı Shepherd dogs in order to identify the breed-specific gait characteristics and obtain the reference values for early diagnosis of the diseases. The force data were classified and analyzed based on plantar areas. For this purpose, 20 Aksaray Malaklı Shepherd dogs (10 females and 10 males) that were 18–36 months old were used. The dogs to be included in the study underwent a preliminary examination for lameness and the healthy ones were detected. Pressure-sensitive gait analysis system was used to obtain gait data. The dogs walked on the pressure platform for two rounds including an average of 20 steps in each at normal walking speed and temporospatial analysis, kinetic gait analysis, and postural static analysis were conducted. The plantar pressure distribution parameters, maximum pressure (N/cm^2), maximum force (N), and time maximum of contact phase (%) were analyzed. It was found that the dog carried 66.55% of its total weight on its forelimbs and 33.45% of its total weight on its hindlimbs at postural stance and the difference between them was statistically significant. The maximum force was applied in the third and fourth digital pads in the forelimb and hindlimb. The force values on metapodial pads were lower than those of the other plantar areas. While the mean stance and swing phases were respectively 63.79% and 36.21% for forelimb, they were 56.38% and 43.62%, respectively, for hindlimb. Both static and all kinetic data revealed that a higher force was generated on the forelimb compared to the hindlimb during walking. Anatomically specific walking characteristics of the animals can be revealed using gait analysis systems. It is also a quite beneficial method for veterinary orthopedics that is based on visual examination.

Key words: Kinetic gait analysis, Malaklı Shepherd dog, stance phase, swing phase temporospatial analysis

1. Introduction

Aksaray Malaklı Shepherd dog is commonly found in the Central Anatolia region in Turkey and takes its name from Aksaray Province where it is reared at most [1]. This dog breed belongs to group of Karabash. Aksaray Malaklı Shepherd dog has large body size, short hair coat, large head and mouth size, drooping lips and less curly tail when compared to Kangal belonging to this dog breed group. All of these morphological characteristics distinguish Aksaray Malaklı Shepherd dogs from Kangal dogs. Some studies have reported that Aksaray Malaklı Shepherd dogs which are one of the largest dog breeds of both Turkey and world descend from a genetically common ancestor with Kangal dogs; however, they have very different morphological characteristics [2].

Gait analysis is a systematic study performed by measuring motions and activities occurring during walking [3]. Gait analysis systems have been started to be frequently used in the diagnosis of invisible walking defects, treatment planning and evaluation of treatment outcomes, and assessing efficacy of orthoses and prostheses [4]. Gait analysis is crucial in particularly neuromuscular diseases [5]. Gait analyses have a wide area of usage in many disciplines of medicine primarily orthopedics. In recent years, these analyses have started to be used in veterinary medicine, as well [6–8]. The most fundamental biomechanical methods are known as the methods performed using image capture systems [9,10]. Even though some walking problems can be diagnosed based on observation, nonetheless, quantitative gait analysis technology should be used for quantification of the problem and evaluation of the treatment efficacy [11]. There are many different methods of gait analysis. Kinetic, kinematic and electromyographic parameters of gait can be obtained using these gait analysis methods [12]. Pressure sensitive walkway (PSW) is one of the mostly developed

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gait analysis systems. It is the walking plate that analyzes the pressure applied by the foot sole contacting the ground [13,14]. PSW is a system that can assess the pressure values applied on the ground by each foot separately and record the temporospatial gait parameters (stance phase, swing phase, step length, and step width, etc.) This system can be used for the tests such as center of pressure (COP) that provides data also about walking balance [8,15]. The pressure changes occurring during walking form a butterfly-shaped graph in the computer. This graph gives information about gait problems by examining the abnormal irregularities [6,16]. The forces that create the movement such as ground reaction force, joint moments and joint forces are analyzed in the kinetic analysis. The only data that can be directly measured by force platforms is ground reaction force vector [11].

Gait pattern is specific for each breed. The studies conducted on different dog breeds have revealed this specificity [6–8]. It has been reported that specific gait disorders can be identified based on data obtained by gait analysis and altered gait pattern can be detected in the neuromuscular, orthopedic and metabolic diseases using these data, and early diagnosis could be established for possible cases [17–19]. For this purpose, the present study aimed to identify the gait parameters of Aksaray Malaklı Shepherd dogs in order to determine the breed specificity and to obtain the reference values for early diagnosis of the diseases. The force data were classified and analyzed based on plantar areas. In addition, forelimb and hindlimb were compared in terms of these data.

2. Materials and methods

2.1. Samples

In the present study, 20 Aksaray Malaklı Shepherd dogs (10 females and 10 males) aged between 18 and 36 months were used. The physical and orthopedic conditions of the selected dogs were examined in before gait analysis. They walked on the Zebris FDM - 2 (Full Balance, İstanbul) PSW system for the analyses. The dogs walked on the pressure platform for two rounds including an average of 20 steps in each at normal walking speed. Mean right and left step values were recorded for forelimb and hindlimb. The differences between right and left step force values were overlooked. The force data of forelimb and hindlimb were compared in the study. The approval for the study was obtained from Animal Experiments Local Ethics Committee of Harran University (Decision No: 2020/006/2020).

2.2. Temporospatial and kinetic gait analysis

The dogs walked on a plate having a length of 241 cm, width of 56 cm, and thickness of 2.1 cm. The images were processed, and numerical data were created through a camera that recorded the movement during walking and a computer connected to the plate. The data of pressure forming during the contact of foot on the ground were transferred to the computer through 8360 pressure sensors on the plate. The three-dimensional pressure plot and pressure change were created for the gait (Figure 1). The results of pressure and force distributions on each digital pad (DP) and metapodial pad were recorded separately (Figure 2).

Mean time of step on the plate, the number of the steps per unit time (cadence) and mean speed were determined to be 0.60 s, 116–117 steps and 3.99 km/h, respectively, and the dogs walked with these values. Center of pressure (COP) analysis was performed to determine the balanced walking in dogs during gait analysis. The analysis results of the dogs that were detected to have walking abnormality according to this analysis were not taken into consideration.

DP3 and DP4 made up the front part of the foot pressure map and the force data of these two digits were evaluated together. The results of DP2 and DP5 constituted the middle part of foot zone. The force data of these two digits were also evaluated together. Metapodial pads made up the hind part of foot sole and force data of this zone were separately analyzed.

2.3. Postural static analysis

The dogs were awaited at normal posture without moving on all four legs contacting the ground on the plate for 20 s. Then, the data were recorded to the computer software for 10 s and distribution of body weight for the legs was calculated (Figure 3).

2.4. Statistical analysis

SPSS 22.0 software was used for statistical analysis of data. Postural static analysis was carried out using independent samples t test. ANOVA test was used for temporospatial and force analyses. Whether or not results were homogeneously distributed was detected by Levene's test. The p values were obtained and presented in Tables 1–4.

3. Results

It was found that the dogs walked with a mean velocity of 3.99 km/h and 116.167 step/min cadence. Mean time of a step was recorded as 0.6 s. Step length, stride length, and paw width were 59.20 ± 9.13 cm, 119.10 ± 22.48 cm, and 15.10 ± 4.46 cm in male dogs, respectively. Step length, stride length, and paw width were determined to be 52.0 ± 10.99 cm, 108.9 ± 19.56 cm and 12.70 ± 4.11 cm in female dogs, respectively. The mean stance and swing phases were, respectively, 63.79% and 36.21% for forelimb and 56.38% and 43.62%, for hindlimb.

The plantar pressure distribution parameters, maximum pressure (N/cm^2), maximum force (N), and time maximum of contact phase (%) were analyzed. Mean, standard deviation, and statistical values of these parameters were obtained for forelimb and hindlimb.

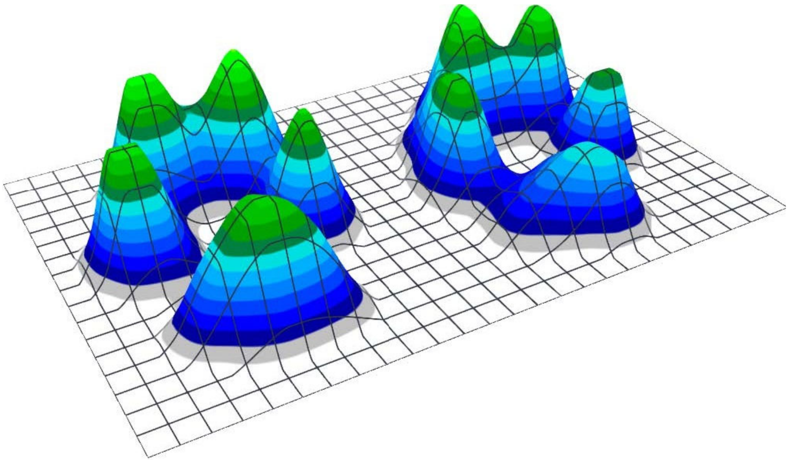

Figure 1. 3D view of foot pressure map.

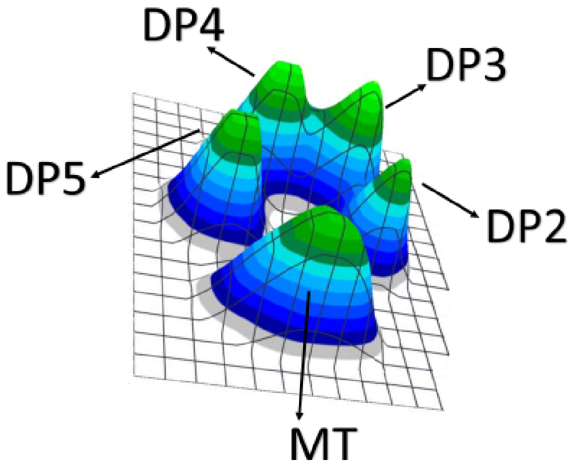

Figure 2. Foot zone analysis digital pad and metapodial pats. DP2: Digital pad 2, DP3: Digital 3, DP4: Digital Pad 4, DP5: Digital Pad 5, MT: Metapodial Pad.

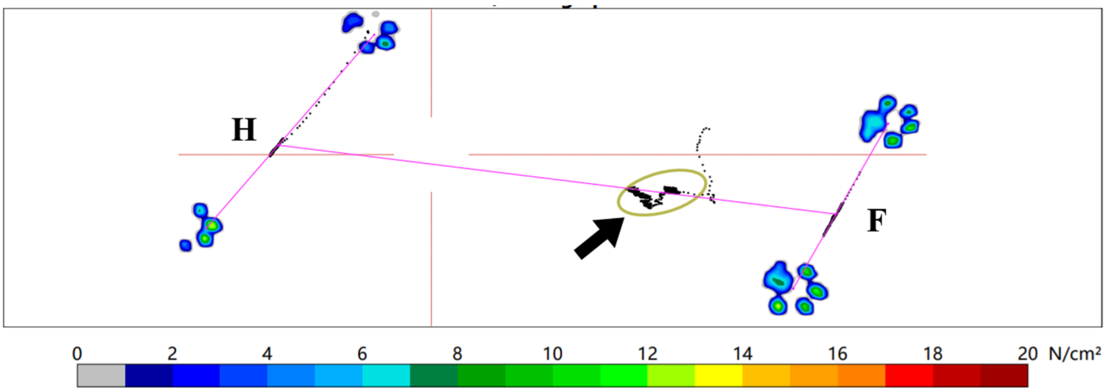

Figure 3. Static distribution result image of a 3.5-year-old male Malaklı Shepard dog. Black arrow: 95% confidence interval. F: Forelimb.

Data of maximum force generated in the foot zone were presented separately for forelimb and hindlimb in Table 1. Of those data, DP3 + DP4 results did not show a homogeneous distribution. All the other results

Table 1. ANOVA results of the maximum force in the foot zones (N).

Foot zone		N	Mean	SD	Min	Max	df	F	p value
DP3 + DP4	Forelimb	40	162.22	43.93	73.90	264.70	1	6.229	0.015
	Hindlimb	40	141.06	30.73	90.70	253.20	78		
DP2 + DP5	Forelimb	40	135.57	26.97	81.80	195.10	1	59.451	0.000
	Hindlimb	40	93.69	21.28	49.20	154.50	78		
Metapodial pad	Forelimb	40	110.99	33.40	57.00	214.00	1	21.475	0.000
	Hindlimb	40	78.90	28.33	19.00	168.60	78		

Table 2. ANOVA results of the maximum pressure in the foot zones (N/cm^2).

Foot zone		N	Mean	SD	Min	Max	df	F	p value
DP3 + DP4	Forelimb	40	22.54	5.19	12.30	34.70	1.00	0.68	0.411
	Hindlimb	40	21.19	8.97	15.00	71.00	78.00		
DP2 + DP5	Forelimb	40	22.22	4.43	16.20	34.30	1.00	27.17	0.000
	Hindlimb	40	17.40	3.82	11.30	32.50	78.00		
Metapodial pad	Forelimb	40	16.45	4.15	9.40	29.20	1.00	0.04	0.834
	Hindlimb	40	16.14	8.25	9.40	62.60	78.00		

Table 3. ANOVA results of the time maximum force (% stance phase).

Foot zone		N	Mean	SD	Min	Max	df	F	p value
DP3 + DP4	Forelimb	40	68.24	9.52	39.50	83.50	1.00	8.79	0.004
	Hindlimb	40	61.16	11.71	40.10	78.60	78.00		
DP2 + DP5	Forelimb	40	53.92	9.08	28.80	72.00	1.00	32.01	0.000
	Hindlimb	40	40.85	11.45	16.90	65.70	78.00		
Metapodial pad	Forelimb	40	35.41	8.61	22.00	58.40	1.00	41.61	0.000
	Hindlimb	40	23.55	7.70	8.50	37.80	77.00		

Table 4. Static distribution data and standard deviations of Malaklı Shepard dogs (%).

	N	Mean	SD	p Value
Forelimb	20	66.55	5.23	0.000
Hindlimb	20	33.45	5.23	0.000

were homogeneously distributed. The forelimb data for maximum force were higher. This difference was statistically significant for whole foot zone. The maximum force value was encountered in DP3 + DP4. The lowest force value was obtained in the metapodial pads.

Maximum pressure per centimeter square was examined in Table 2. All the results were homogeneously distributed for maximum pressure data. The maximum pressure values per centimeter square were detected in the 3rd and 4th digital pads. The values of forelimb were higher than those of hindlimb in terms of all data. However, only the results of the 2nd and 5th digital pads were statistically significant.

Table 3 shows the time maximum of contact phase (%). It was observed that a longer lasting force was generated in the forelimb in the time maximum of contact phase (%). The difference between the times for all the analyzed digital pads and metapodial pad was statistically significant.

Table 4 shows the static distribution of force at postural stance. It was found that the dog carried 66.55% of its total weight on its forelimbs and 33.45% of its total weight on its hindlimbs at postural stance and the difference between them was statistically significant.

4. Discussion

The pressure values of the foot plantar areas contacting the ground were examined in the present study. It was determined that DP3 and DP4 had the maximum force values for forelimb and hindlimb, which was followed by DP2 and DP5. When examining maximum force values of metapodial pads for forelimb and hindlimb, it was determined that the values of forelimb were higher than those of hindlimb. Gundemir et al. [7] reported in their study on Akbash and Kangal dogs that maximum force values of metapodial pads were higher in hindlimb than forelimb. Souza et al. [20] reported that maximum force was applied in the metapodial pad of the forelimbs and digital pad 3 and digital pad 4 in hindlimbs in the pitbull dogs. Souza et al. [21] have noted that maximum force was high in the digital pads of the forelimb and hindlimb in German Shepherd dogs. Besancon et al. [22] stated that maximum force was applied in the metapodial pads of forelimbs and hindlimbs in greyhounds whereas maximum force was applied in metapodial and digital pads of forelimbs and hindlimbs in Labrador dogs, respectively. Gundemir et al. [6] reported that digital pads of forelimbs and hindlimbs demonstrated the maximum force in English setter dogs.

In the present study, the mean stance and swing phases during walking were determined to be, respectively, 63.79% and 36.21% for forelimb and 56.38% and 43.62% for hindlimb. Gundemir et al. [7] reported stance and swing phase values of 67.73% and 32.27% in gundogs, respectively. Data on stance and swing phase obtained by gait analysis system can serve as a potential adjuvant diagnostic tool in the diseases of locomotor system that manifest with lameness especially in veterinary medicine [23].

It was observed that Aksaray Malaklı Shepherd dogs applied 66.55% of static distribution on forelimb and the remaining percentage of the static distribution on hindlimb at normal posture. Gundemir et al. [7] reported in their study on Akbash and Kangal shepherd dogs that these dogs applied 62.25% and 37.75% of mean force on their forelimb and hindlimb, respectively. Distribution of mean force was 64.58% and 35.42% in the forelimb and hindlimb, respectively in gundogs [7].

Consequently, we consider that our pilot study showing the gait kinetic characteristics and gait parameters of Aksaray Malaklı Shepherd dogs would provide a basis for increasing scientific studies and use of these methods for routine diagnosis, treatment and prognostic evaluations particularly in the fields of neurology and orthopedics in the future.

Conflict of interest

The authors declare that they have no conflict of interest.

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