Dicle Üniversitesi Veterinar Fakültesi Dergisi
http://www.dicle.edu.tr/veteriner-fakultesi-dergisi

Araştırma Makalesi/Research Article

ISSN:1307-9972 e-ISSN:1308-0679

Center of Pressures (COP) Analysis Using Gait Analysis Systems in Belgian Malinois Dogs: A Pilot Study

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Geliş Tarihi/Received	Kabul Tarihi/Accepted	Yayın Tarihi/Published
16.04.2020	22.05.2020	30.06.2020

Abstract

Temporospatial and kinetic walking data can be obtained by using pressure-sensing walking systems. In this study, the center of pressure (COP) analysis was performed on clinically healthy Belgian Malinois dogs using pressure-sensing walkway. An average of 30 steps were taken by each dog. Gait analyses were carried out without using leash. The butterfly diagram created by pressure center during gait was obtained separately for each dog. Data such as anterior-posterior position, lateral symmetry, length gait and max gait line were recorded in mm using the butterfly diagrams. The average anterior-posterior position value was 60,01 mm and the average lateral symmetry value was 17,48 mm. The Max gait line average was calculated to be 52.23 mm. The objective of this study was to identify reference values for center of pressure analysis conducted on dogs using pressure-sensing walkway. The fact that it was possible to collect butterfly diagram results for dogs and that the values were similar within this study that made use of dogs of the same breed suggest that COP analyses can also be applied to dogs. These systems are thought to be used in applications for better understanding of motion function and development of treatment methods in veterinary orthopedics, neurology and physical therapy.

Key Words: Butterfly diagram, cop analysis, gait analysis

Belçika Malinois Köpeklerinde Yürüme Analizi Sistemleri Kullanılarak Basınç Merkezi (COP) Analizi: Pilot Çalışma

Öz

Basınca duyarlı yürüme sistemleri kullanılarak temporospatial ve kinetik yürüme verileri elde edilebilmektedir. Bu çalışmada klinik olarak sağlıklı Belçika Malinois köpeklerinde, basınca duyarla yürüme plağı kullanılarak basınç merkezi analizi (COP) yapılmıştır. Her bir köpek platformda ortalama 30 adım yürütüldü. Yürüyüş analizleri tasma kullanılmadan yapıldı. Yürüyüş sırasında basınç merkezi tarafından oluşturulan kelebek diyagramı her köpek için ayrı ayrı elde edildi. Önden arkaya poziyon değişimi, yanal simetri farkı, adım sırasında merkezi basınç değişimi ve merkezi basınç değişim çizgisinin uzunluğunun tamamı gibi veriler kelebek diyagram yöntemi kullanılarak mm cinsinden kaydedildi. Ortalama önden arkaya poziyon değişim değeri 60,01 mm olarak ve ortalama yanal simetri farkının değeri ise 17,48 mm olarak kaydedildi. Merkezi basınç değişim çizgisi ortalama 52,23 mm olarak hesaplandı. Bu çalışmada basınca duyarlı yürüme plağını köpeklerde kullanarak, basınç merkezi değerlerinin referans verileri belirlenmesi amaçlandı. Aynı ırk köpeklerden yararlanan bu çalışmada köpekler için kelebek diyagramı sonuçlarının elde edilebilmesi ve değerlerin benzer olması, basınç merkezi analizlerinin (COP) köpeklerde de kullanılabileceğini düşündürmektedir. Bu sistemlerin, veteriner ortopedi, nöroloji ve fizik tedavi alanlarında hareket fonksiyonunun daha iyi anlaşılması ve tedavi yöntemlerinin geliştirilmesine yönelik uygulamalarda kullanılabileceği düşünülmektedir.

Anahtar Kelimeler: COP analizi, kelebek diyagram, yürüme analizi

INTRODUCTION

The Malinois dog is a medium-sized Belgian shepherd dog. Thanks to its agility and performance, it is used for herding, search and rescue and as police dog. Although they resemble German dogs, they are smaller and lighter in build. They have triangular and erect ears (1,2).

Various gait analysis systems have been employed recently in the field of veterinary medicine (3,4). Force and pressure plates are the most preferred ones. These systems were also used in dogs, and gait speed values were obtained in addition to the force applied by the paw surfaces to the ground (4,5). These systems were also applied to dogs to get reference values (6,7). These systems support physicians with numerical data for diagnosis. As in medical medi-

cine, these studies will also contribute to clinical fields in veterinary medicine.

Pressure-sensing walkway allows the pressure applied by the foot on the surface to be measured. In addition, with the help of software programs, the change in the center of gravity can also be recorded during walking. This analysis, which is called center of pressure (COP) that makes use of the change in the pressure center, was employed in various studies with human neurological patients (8,9). There are also studies in veterinary medicine using this system (10). However, there are a limited number of studies available on dogs (11,12).

The COP analyses develops a butterfly-like pattern on 2-D computer environment of changes in the pressure center during walking. Abnormal changes in this pattern represent abnormal movements in gait. This pattern also allows to obtain the numerical data of these abnormal pressure changes (13). This is why this analysis can support physicians especially in the fields of orthopedics and neurology.

In this study, the objective was to evaluate COP analysis tests performed on clinically healthy Belgian Malinois dogs using pressure-sensing walkway. After the COP analysis, we planned to look at numerical differences between individuals. By making use of the analysis, we wanted to see which values, which were previously collected for humans, can be collected for dogs and which data can be used in the field of veterinary medicine.

MATERIALS AND METHODS

Animals

Thirteen clinically healthy Belgian Malinois dogs (11 female, 2 male) whose ages range from 1 to 6 (mean age±ss) were included in the study. Before the dogs were incorporated in the study, their weights were measured, standard physical examinations were performed and no clinical abnormalities like lameness or pain were detected in any dog. Trained dogs that could receive voice commands were included in the study and no leash was used during their walks, as it may affect the data. The study was approved by the Local Ethics Committee of Istanbul University-Cerrahpasa Faculty of Veterinary Medicine (Approval number: 2019-171954) and the dogs' owners provided informed consent.

Gait assessment

Gait parameters were evaluated using the Zebris FDM-2 System (Zebris Medical GmbH, Germany) (Figure 1). The system contains a pressure distribution measuring platform and a camera. The pressure platform has a 203 x 54.2 cm (L x W) sensor area and it measures 212 x 60.5 x 2.1 cm (L x W x H). This platform is equipped with 15,360 force sensors that can measure pressure per square centimeter. During the walk on the platform, recording is also done with a real-time camera.

On the evaluation day, after the general clinical examination, Zebris FDM-2 System was set up in an open area and the dogs walked at the normal walking speed on the platform under the supervision of veterinary physicians. An average of 30 steps were taken from each dog. Measurements were calculated by an experienced veterinary physician.

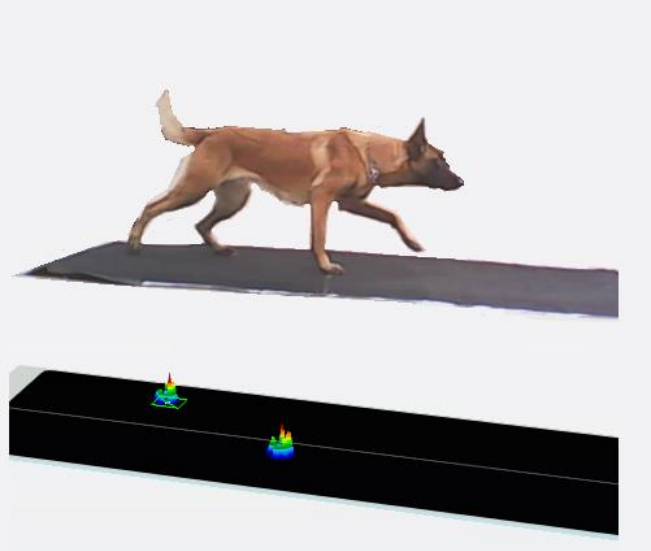

Figure 1. Pressure-sensing walkway

Gait parameters

Zebris FDM Software Suite was used for to calculate the walking parameters and analyze the center of pressure (COP). Cadence, velocity, and step time were obtained by evaluations made during walking. Also, the maximum force value applied by each paw to one-centimeter area was measured.

The software of the system creates a graphic pattern called "butterfly diagram" representing the continuous trace of the COP trajectory during walking. The butterfly diagram occurs as a result of changes in the COP. The following parameters were obtained from the butterfly diagram (13,14):

Anterior/posterior position (mm): Forward or backward shift of the COP intersection point (Figure 2A).

Lateral symmetry (mm): Left or right shift of the COP intersection point (Figure 2B).

Gait line length (mm): The change in the center of gravity of one foot when it touches the floor. Separate values were obtained for right and left foot (Figure 2C).

Max gait line (mm): Total length of lines imprinted by the change in the center of gravity.

Statistical analysis

The SPPS version 20.0 software was used for the statistical analysis. All data was tested for normal distribution by use of the Shapiro-Wilk test. The relationship between variables was evaluated by Spearman correlation analysis. Descriptive statistics are reported as mean ± standard deviation. The level for statistical significance was set at $p \leq 0.05$.

RESULTS

Thirteen dogs completed the study. No unexpected complaint or negative situation were encountered during the

assessments. The values of gait and center of pressure analysis along with the weights of the dogs are shown in Table 1. Different gait speeds were recorded for dogs walking on the platform without a leash. The slowest dog's speed was 2.9 km/h while the fastest ones' was 12.9 km/h.

Table 1. The raw data of the gait analysis of the Belgian Malinois dogs

Dog Number	Weight (kg)	Maximum Force (N/cm²)	Step Time (sec)	Cadence (steps/min)	Velocity (km/h)	Gait Line Length (mm)			Anterior/Posterior Position (mm)	Lateral Symmetry (mm)	Max Gait Line (mm)
						Left	Right	Left-Right Difference			
1	26.1	25.5	0.24	259	9.9	40.6	41.9	1.3	49.8	20.9	47.7
2	24	29.3	0.1	437	10.9	29.6	29	0.6	58.3	8.2	40
3	22.5	24.5	0.1	515	9.7	40.5	42.2	1.7	61.3	24.2	40.6
4	25.1	25.8	0.13	410	5.9	41.2	47.4	6.2	69	12	59.5
5	17.5	13.3	0.2	308	2.9	29.9	27.9	2	55.5	20	47.4
6	21.2	25.3	0.25	261	7.5	35.6	41.2	5.6	52.7	35.5	53.1
7	22.4	24	0.18	326	11.5	56.2	41.5	14.7	55.7	45.6	41.7
8	23.7	27	0.1	575	5.9	26.4	24.5	1.9	59.3	12.9	46.5
9	18.5	17.7	0.1	507	10	39.2	34.9	4.3	58.6	5.4	48
10	19.2	16	0.12	522	6.1	41.6	50.4	8.8	78.4	12.3	95.9
11	22.4	23.5	0.23	267	12.9	29.8	34.1	4.3	56.2	17.2	47.7
12	28.5	34	0.18	333	5.8	18.6	28.2	9.6	56.2	11.4	72.5
13	22	22.5	0.21	245	7.5	36.3	47.4	11.1	69.2	11.7	38.4

There was a significant positive correlation between weight and maximum force (r=0.889, p<0.001). Heavier dogs applied more pressure force onto the ground. In all samples, the highest force occurred in the digital pad area. Pressure force applied by forelimb were higher than hind limb. There was a negative correlation between step time and anterior/posterior position (r=-0.582, p=0.37) and step time and cadence (r=-0.904, p=<0.001). No significant correlation was found between the other variables.

Mean and standard deviation (SD) of gait analysis values are shown in Table 2.

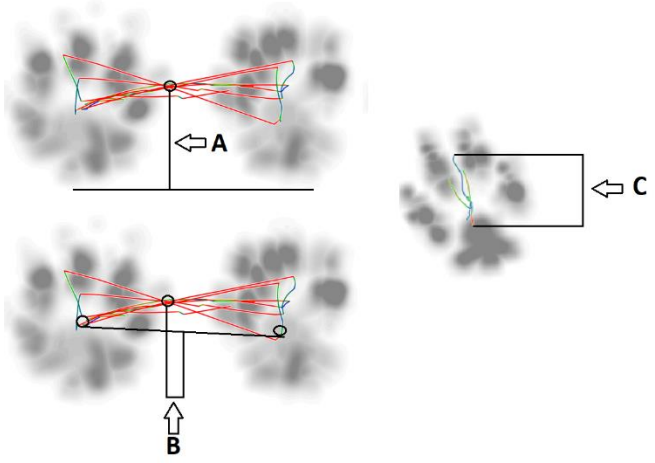

Figure 2. The butterfly diagram, A: Anterior-posterior position, B: Lateral symmetry, C: Length gait

DISCUSSION AND CONCLUSION

The center of pressure (COP) analysis was performed on clinically healthy Belgian Malinois dogs using pressure-sensing walkway. Force and Pressure sensitive walkway plates are advantageous for obtaining specific data about kinetic parameters. These systems support physicians with numerical data for diagnosis. As in medical medicine, these studies will also contribute to clinical fields in veterinary medicine.

Force values of forelimb and hindlimb are taken. Important information on the biomechanics of Belgian Malinois bred have been accorded to these values. Thanks to the static measurement, the stance characteristics of Belgian Malinois breed were obtained numerically.

It was observed that some dogs were afraid of the platform and that could cause wrong results about the analysis. At this stage, the dogs were passed through the platform several times before the recordings were made to ensure that the results are correct. We got the results when they walked balanced and fearless.

We think that the COP analysis should be developed further in the field of veterinary medicine. The numerical data given by this system will be very valuable in the diagnosis of orthopedic disorders that may arise especially from the neurological diseases of dogs and during recovery. With these features, PSW system is thought to have an important place in veterinary medicine.

Forces applied by front and hind feet were analyzed separately in the studies conducted using the pressure-sensing walkway system and a contribution was made to the literature. As in previous studies, this study also found that during gait, force applied by forefeet were higher than hind feet (15-17). It was also observed that the maximum force value achieved in the digital pad area.

COP analysis was previously performed on dogs with neurological problems using markers (12) and these studies achieved similar results with the butterfly diagram in this study. No leashes or markers were used on dogs in this study. Previous studies suggested that leash had an impact on gait force values (18,19). This the reason why dogs that can respond to voice command were used. This way, the aim was to further optimize reference values to be obtained using the COP. Length values for each foot were obtained using the COP analysis and these two values were found to be quite close for each dog. We think that lateral

symmetry will be of importance for future COP analysis studies. In previous studies, the COP analysis was conducted on humans to measure and compare lateral symmetry data on healthy individuals and individuals with neurological problems (13,20). We believe that the values collected from dogs that were walked without being on a leash and exposed to any external effects can be used in future neurological studies.

Gait analysis systems have also been used in the field of veterinary medicine. This system will physicians to make the correct diagnosis by making use of numerical data during examination. Thanks to the software used in these systems, it is possible to gain information on gait morphometry by looking at the pressure applied by dogs on the ground. The objective of this study was to identify reference values for center of pressure analysis conducted on dogs using pressure-sensing walkway. The fact that it was possible to collect butterfly diagram results for dogs and that the values were similar within this study that made use of dogs of the same breed suggest that COP analyses can also be applied to dogs. Thanks to this feature, pressure-sensing walkway systems are thought to be applicable in veterinary neurology. It is thought that such systems will play an important role in fields of veterinary anatomy, orthopedics and neurology and the number of such studies will increase.

ACKNOWLEDGEMENTS

We would like to thank Nergis PEHLİVAN for her support in the walking analyses and interpretation of these analyses and Von Juliet Dog Academy for letting us to make use of the dogs in the study.

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