

Incidence, genetic predisposition, and recovery by physiotherapy of orthopedic disorders in dogs and cats

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Abstract. The present work aimed to establish the incidence of various of orthopedic disorders in dogs and cats. There were discussed aspects of genetic predisposition and recovery by physiotherapy. Investigations were conducted on 2765 dogs and cats, among which 45 (1.63%) were diagnosed with orthopedic conditions that required physiotherapy. Considering the specie and sex of diagnosed individuals, their vast majority was represented by dogs (82.22%), the difference being represented by cats (17.78%), with a prevalence of males in both specie. Orthopedic disorders that required physiotherapy diagnosed during this study were represented by diseases due to nutritional deficiencies (rickets – 4.44% of all orthopedic cases), bone trauma (fractures - 62.22% of all orthopedic cases), and joint diseases (hip dysplasia - 46.67% of all orthopedic cases; aseptic necrosis of the femoral head - 40% of all orthopedic cases; coxo-femoral dislocation and patellar dislocation - 6.67% each). Their recovery by physiotherapy procedure associated to conservative and surgical treatment was different in the number of days, depending on the type of disease: 20-40, for bone injuries and joint diseases; 20, for coxo-femoral and patella dislocations; 10, for rickets.

Key Words: rickets, bone trauma, and joint diseases, aquired pathology and genetic predisposition

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Introduction

In the context of musculoskeletal disorders in pet carnivores, orthopedic ones are characterized by a higher degree of reversibility and recovery compared to neurological ones, although their symptoms can also be dramatic (Colvero et al 2020). Orthopedic diseases can be found at any of the three levels represented by bones, muscles, and tendons, having congenital or acquired origins. Often an association of these two factors can be found, the genetic predisposition favoring various types of orthopedic diseases (reviewed by Henea 2020).

The therapeutic approach is different according to the type of orthopedic diseases, those with inflammatory causes having a specific non-inflammatory medication, while in those degenerative, the conservative treatment, associated or not with the surgical one, may be completed by a subsequent administration of analgesic and anti-inflammatory substances and, depending on the case, of mineral supplements. Various physiotherapy techniques, as a complementary therapeutic procedure, have increased the healing rate of the affected individuals even until the complete remission of the presented clinical signs (Marks et al 2017; Pinna et al 2015).

In this paper we aimed to present the incidence, genetic predisposition, and recovery by physiotherapy of orthopedic disorders in dogs and cats. Various aspects of originality are presented, considering the classification of orthopedic diseases in pet carnivores and the incidence of each type of disease considering various criteria of diagnostic

Materials and Methods

2765 dogs and cats were investigated in the Medical and Surgery Clinics of the Faculty of Veterinary Medicine of Iași, of which 45 (1.63%) were diagnosed with orthopedic disorders which required physiotherapy. The orthopedic evaluation was customized as the case may be, but in general, the anamnesis and initial observations in the resort and on the walk were associated with the clinical examination by palpation, flexion and extension, rotation, comparative measurement of limb length and angles. For compliance, additional radiological examinations were performed as needed. The incidence of various orthopedic diseases was established according to specie, sex, age, and breed.

Results

2765 dogs and cats were investigated, 134 (4.62%) of these being diagnosed with diseases that required physiotherapy, including 45 (1.55% of the total) with orthopedic conditions and 89 (3.07% of the total) with neurological ones (Figure 1).

Considering the specie and sex of individuals diagnosed with orthopedic conditions that required physiotherapy, their vast majority was represented by dogs (37; 82.22%), the difference being represented by cats (8; 17.78%). In the case of dogs, 19 were males (51.35%) and 18, females (48.65%); males prevailing was also observed for cats, with 6 males (75%) and 2 females (25%) (Figure 2).

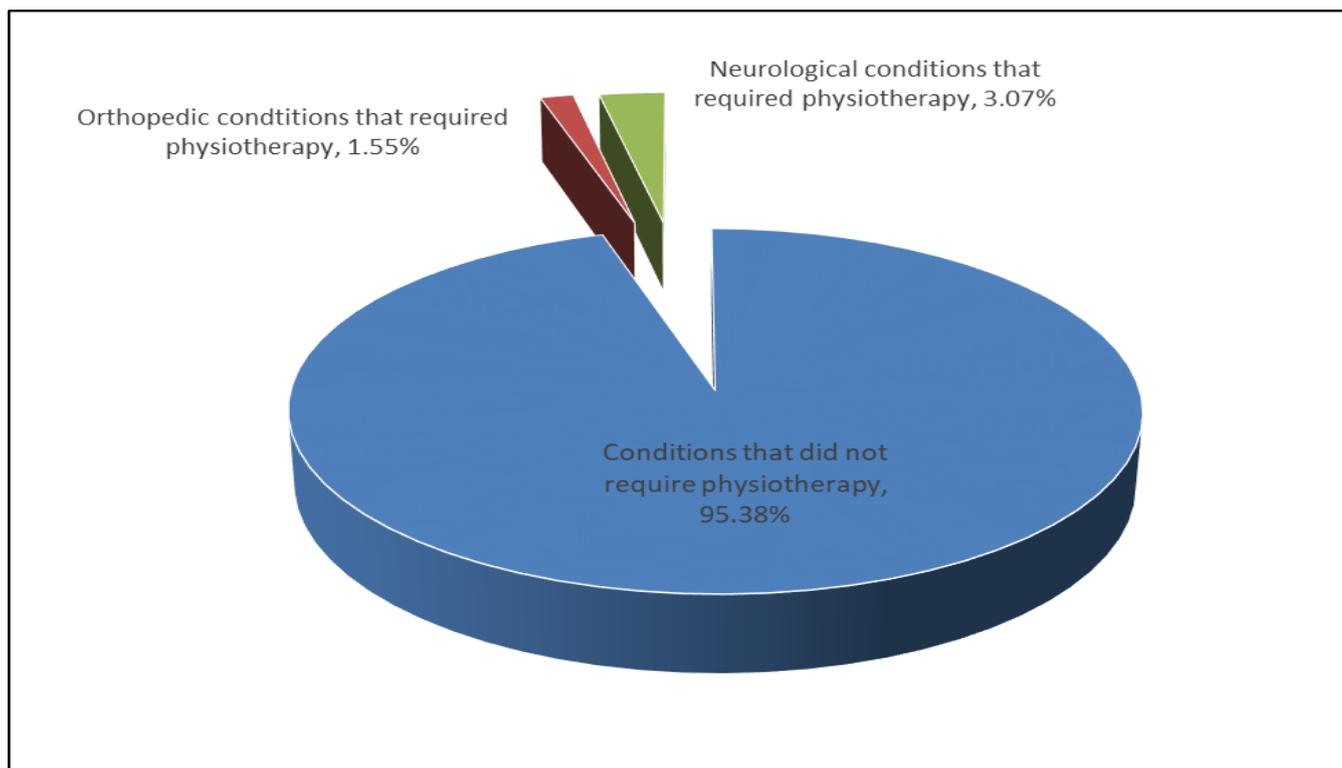


Fig.1: Major types of conditions diagnosed during the period of study

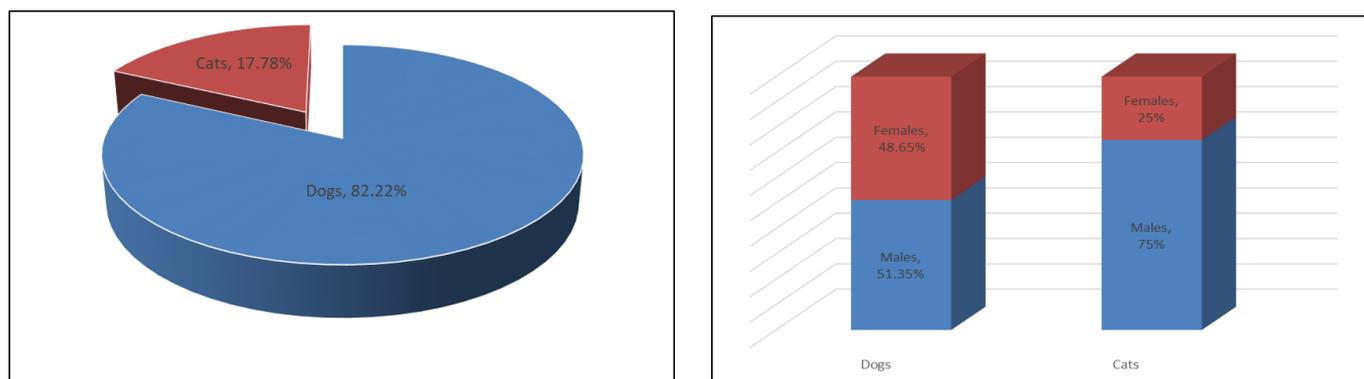


Fig.2: The incidence of orthopedic disorders that required physiotherapy by specie and sex

Orthopedic disorders (that required physiotherapy) diagnosed during this study were represented by diseases due to nutritional deficiencies, bone trauma, and joint diseases.

In the group of diseases due to nutritional deficiencies we have included two rickets cases represented by two male dogs. The diagnosed bone injuries were only fractures (28 individuals, 62.22% of all orthopedic cases), most of them affecting the hind limbs (18 individuals; 64.29% of all fractures), the difference being of the front limbs (10 individuals; 35.71% of all fractures). Of the 18 cases that affected the hind limbs, 11 were found in dogs (61.11%) and 7 in cats (38.89%). The 11 dogs affected were 3 males (27.27%) and 8 females (72.73%), and the 7 cats were 5 males (71.43%) and 2 females (28.57%). Regarding front limb fractures (10 cases), 9 of them were found in dogs (90%) and one in cats (10%); of the dogs thus diagnosed, the majority were male (7; 77.78%) and the difference, females (2; 22.22%). Joint diseases were found in 15 individuals out of a total of 45 with orthopedic disorders (33.33%). These were hip dysplasia (7 individuals; 46.67% of all orthopedic cases), aseptic necrosis of the femoral head (6 individuals; 40% of all

orthopedic cases), coxo-femoral dislocation and patellar dislocation, one case each (6.67% each). Joint diseases were found only in dogs, as follows: the 7 dogs with hip dysplasia were 2 males (28.57%) and 5 females (71.43%), the 6 dogs with aseptic necrosis of the femoral head were 4 males (66.67%) and 2 females (33.33%), the dog with coxo-femoral dislocation was a male and the one with patellar dislocation, a female (Table 1). Among bone fractures diagnosed in the hind limbs (18 cases), there were those of the femur (12 cases; 66.67%), of the pelvis (4 cases; 22.22%), those associated of femur and tibia (1 case; 5.56%), and those of phalanges (1 case; 5.56%). The 12 cases of femoral fractures were found in 9 dogs (75%) and 3 cats (25%), 2 males (22.22%) and 7 females (77.78%) in the case of dogs, and only males in the case of cats. The 4 pelvic fractures were found in one dog (25%) and 3 cats (75%), one male dog, and one male (33.33%) and 2 females (66.67%) in the case of cats, respectively. Associated fractures of femur and tibia were found in a male cat, but the phalanx fractures in a female dog (Table 2).

Table 1. The incidence of orthopedic diseases that required physiotherapy depending on specie and sex

Orthopedic disorders that required physiotherapy	Subtypes	Dogs				Cats				Total #
		Males		Females		Males		Females		
		#	%	#	%	#	%	#	%	
Diseases due to nutritional deficiencies	Rickets	2	100	-	-	-	-	-	-	2
	Total #	2				-				
Bone fractures	Of hind limbs	3	27.27	8	72.73	5	71.43	2	28.57	28
	Total #	11				7				
		18								
	Of front Limbs	7	77.78	2	22.22	1	100	-	-	
	Total #	9				1				
		10								
Joint diseases	Hip dysplasia	2	28.57	5	71.43	-	-	-	-	15
	Total #	7				-				
		7								
	Aseptic necrosis of the femoral head	4	66.67	2	33.33	-	-	-	-	
	Total #	6				-				
		6								
	Coxo-femoral dislocation	1	100	-	-	-	-	-	-	
	Total #	1				-				
	1									
Patellar dislocation	-	-	1	100	-	-	-	-		
Total #	1				-					
	1									

Table 2. The incidence of bone fractures of the hind limbs by specie and sex

Types	Subtypes	Dogs				Cats				Total #
		Males		Females		Males		Females		
		#	%	#	%	#	%	#	%	
Bone fractures of the hind limbs	Of femur	2	22.22	7	77.78	3	100	-	-	12
	Of pelvis	1	100	-	-	1	33.33	2	66.67	4
	Associated of femur and tibia	-	-	-	-	1	100	-	-	1
	Of phalanges	-	-	1	100	-	-	-	-	1
		18								

Table 3. The incidence of bone fractures of the front limbs by specie and sex

Types	Subtypes	Dogs				Cats				Total #
		Males		Females		Males		Females		
		#	%	#	%	#	%	#	%	
Bone fractures of the front limbs	Of humerus	4	80	1	20	1	100	-	-	6
	Of radius	1	50	1	50	-	-	-	-	2
	Associated of radius and ulna	2	100	-	-	-	-	-	-	2
		10								

Among the fractures diagnosed in the front limbs (10 cases), there are those of the humerus (6 cases; 60%), radius (2 cases; 20%), and those associated of radius and ulna (2 cases; 20%). Humerus fractures were found in 5 dogs (83.33%) and one cat (16.66%), of the 5 dogs, 4 being male (80%) and one female (20%); the cat was a male. Radius fractures were found only

in 2 dogs, one male and one female, and associated radius and ulna fractures, in 2 male dogs (Table 3).

The 2 cases of rickets diagnosed in our clinic during the investigations were found in dogs aged < 2 years.

Of the total 11 cases of hind limb fractures in dogs, the most affected was the femur with 9 cases (81.82%), 6 cases of them (54.55%) being found in dogs < 2 years of age, and the

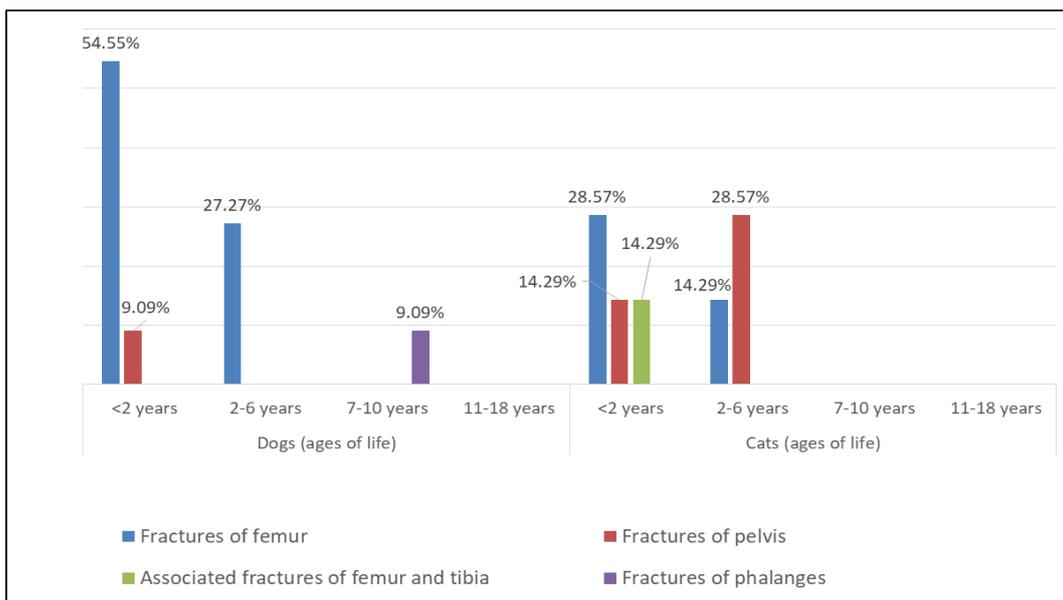


Fig.3: The incidence of hind limb fractures by specie and ages of life

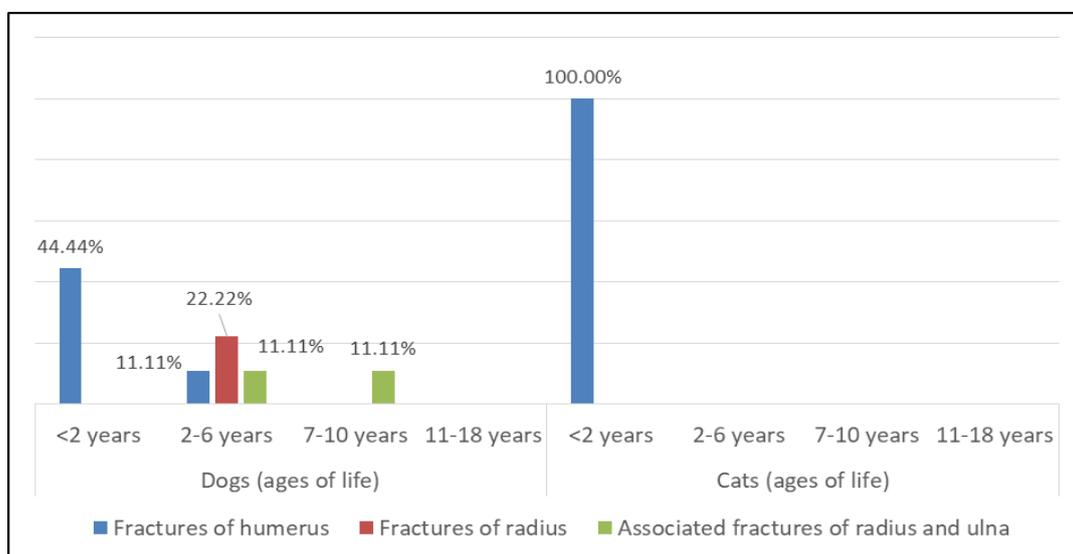


Fig.4: The incidence of front limb fractures by specie and ages of life

difference, in dogs aged between 2 and 6 years (27.27%). The fractures of pelvis and of phalanges in dogs were represented by one case each, the pelvis fracture being found in the group < 2 years of age (9.09%), and the fracture of phalanges in the group of 7-10 years of age (9.09%). In cats, the incidence of fractures diagnosed in hind limbs was lower compared to dogs (7 vs. 9), the femur and pelvis being under the same incidence, 3 cases each. Femur fractures in cats (42.86%) were mostly found in the group of < 2 years of age (2 cases; 28.57%), the difference (one case; 14.29%) being found in the group of 2-6 years of age. In the case of fractures of pelvis in cats, their incidence was the reverse of those of the femur, most of them being found in the group 2-6 years of age (2 cases; 28.57%), and the difference (one case; 14.29%) in the group < 2 years of age. In the group of fractures of the hind limbs was also included one case of associated fracture of femur and tibia in a cat < 2 years of age (14.29%) (Figure 3).

Considering the fractures of the front limbs, they had a lower incidence compared to those of the hind limbs in both dogs and cats. The 9 cases of fractures of the front limbs diagnosed in

dogs were distributed as follows: 5 of them affected the humerus (55.55%), the majority (4 cases; 44.44%) being found in the group of age < 2 years, and the difference (one case; 11.11%), in the group 2-6 years of age. Radius fractures and those associated of radius and ulna had an equal incidence of 2 cases each, radius fractures (22.22%) being found in the group 2-6 years of age, while those associated of radius and ulna (22.22%) were found evenly distributed, one case each in the groups 2-6 years of age (11.11%) and 7-10 years of age (11.11%), respectively. During the investigations, only one case in the cat was diagnosed with a fracture of a front limb, namely a humerus fracture in a cat < 2 years old (100%).

Considering the joint diseases, the 15 cases thus diagnosed were found only in dogs. 7 cases (46.67%) were represented by hip dysplasia, 4 of them (26.67% of the total joint diseases) being found in dogs < 2 years of age, and 3 (20% of the total joint diseases), in dogs aged between 2 and 6 years. The 6 cases of aseptic necrosis of the femoral head were found in dogs < 2 years (40%). The two cases of coxo-femoral dislocation and patellar dislocation were found, one in the category 7-10 years,

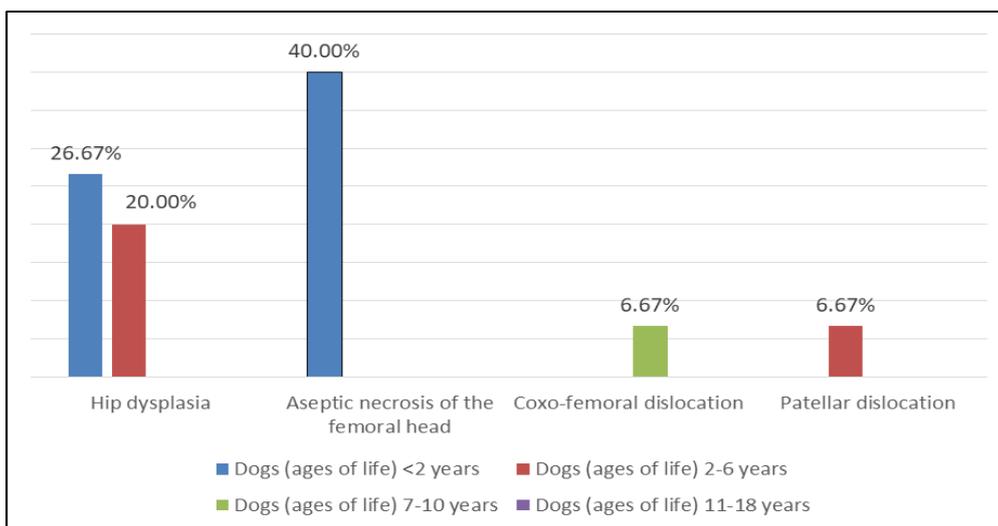


Fig.5: The incidence of joint diseases in dogs by ages of life

for coxo-femoral dislocation (6.67%), and the other one in the category of 2-6 years of age, for patellar dislocation (6.67%) (Figure 5).

Considering the distribution of orthopedic diseases by specie and breeds, those due to nutritional deficiencies (rickets) were found in half-breeds dogs, not in cats (2 cases). Of the 9 cases of femoral fracture in dogs, the vast majority was found in half-breeds (7; 77.78% of cases of femoral fracture), with a subsequent equal distribution of one case each in Yorkshire breeds (11.11% of cases of femoral fracture) and German Shepherd (11.11% of cases of femoral fracture). The two dogs diagnosed, one with a pelvic fracture and the other with a fracture of phalanges, were half-breeds. Regarding the fractures of the front limbs in dogs, regardless of their location, they were found only in half-breeds. Regardless the location of the front or hind limbs` fractures in cat, they were found in a single breed, the European one. Considering joint diseases in dogs, the 7 cases of hip dysplasia were found in Labrador breeds (2 cases; 28.57% of cases of hip dysplasia), Rottweiler, Bernese Shepherd, Golden Retriever, and German Shepherd (one case each; 14.29% each), as well as in half-breed dogs (one case; 14.29%). The Bichon breed was the only one affected by aseptic necrosis of the femoral head (6 cases), as well as by patellar dislocation (one case). The only case of coxo-femoral dislocation diagnosed during the research was found in a half-breed dog. Orthopedic joint disorders have not been found in cats.

Discussions

The diagnosis and therapy of orthopedic diseases are particularly important in ensuring a daily post-injury normality, these disorders usually affecting the bone but also the soft tissues and / or joints. In the present study, of the 45 dogs and cats with orthopedic conditions that required physiotherapy, the majority of diagnoses were fractures (28 cases; 62.22%), with a higher incidence in dogs (20 cases; 71.43%) compared to cats (8 cases; 28.57%), and with a more frequent involvement of the hind limbs compared to the fore limbs (18 cases; 64.29% and 10 cases; 35.71%, respectively), both in dogs and cats. The most common cause of these diseases is car accidents, a fact confirmed by the distribution by breeds, being affected half-breed dogs and

cats of European breed, but also by age, being mainly affected young animals, < 2 years of age and 2-6 years of age, without urban experience or negligence on possible dangers, especially during the ruth period. The greater number of affected dogs compared to affected cats is related to a large number of cases of this specie during the investigations. On the other hand, cats may not survive to car accidents, being usually crushed under the wheels of the cars. It should be noted that of the total fractures, those of the femur had the highest share in both dogs and cats, with an almost double rate and, sometimes, even higher than other fractures of other long bones (this being in relation to the fact that the femur becomes vulnerable due to its longer length compared to that of other bones). The therapy of fractures in animals is a complex process that involves, as the case may be, an operative component, with the installation of a rod, or only the immobilization of the affected limb, accompanied in both cases by physiotherapy procedures. Drug treatment is important in terms of limiting pain and preventing complications. After surgery, a special attention is paid to the return of the animal in terms of water and food consumption, urination and defecation, maintaining cleanliness and avoiding decubitus wounds. Physiotherapy procedures are important, taking into account the animal's tendency to avoid using the affected limb, which will lead to shortening of ligaments and tendons, as well as muscle atrophy in the region. The results obtained in our investigations were different depending on the promptness of application of post-trauma physiotherapy procedures. The establishment of physiotherapy programs at 5-7 days after surgery determined a complete recovery after 20 sessions, and later than 7 days, after 40 sessions. It is worth mentioning that the physiotherapy sessions were applied daily, 60 minutes per patient, and consisted of electrostimulation with a low frequency current, with the application of four surface electrodes at the motor points corresponding to the affected region, massage for muscle relaxation, and a range of active movements with the ball or balance platform.

On a second place in the incidence of orthopedic diseases (after bone injuries), we found the joint diseases represented by hip dysplasia and aseptic necrosis of the femoral head, diagnosed only in dogs.

Hip dysplasia is an osteoarthritis or degenerative joint disease, where poor development of the pelvis causes excessive wear of the joint surface, with changes in the femoral end and acetabular cavity by flattening them. Clinically, there is a laxity of the affected soft tissues and a regional instability, due to the inability of the structures to maintain the congruence of the femoral head with the acetabular cavity. Hip dysplasia can also occur due to the disproportion between the regional muscle mass and the too rapid growth of the skeleton, this being confirmed by the low incidence of the disease in dogs with a well-developed muscle mass. Cases investigated in our study demonstrated that hip dysplasia is a condition of young dogs, affecting those < 2 years and those aged between 2 to 6 years of age. As in the study of Loader and Todhunter (2017), our investigative data show a higher frequency of hip dysplasia among females. The frequency of hip dysplasia among Labrador dogs was double compared to that found in half-breeds, Rottweiler, Bernese Shepherd, Golden Retriever, or German Shepherd, but before formulating a firm conclusion in this regard we must take into account the small number of cases at hand on this pathology in the present investigation. However, Simon *et al* (2010) also reported an increased incidence of hip dysplasia in Labrador Retriever breed compared to other breeds such as Alsatian, Golden Retriever, Rottweiler, Doberman, Pinscher, St. Bernards, Neopolitan Mastiff and others.

A number of genetic factors seem to be associated with hip dysplasia, this condition being recognized with polygenic origin and an influence of the environmental factor through what involves diet and activity. Studies in the field have found different values of the heritability coefficient (h^2), between 0.11 and 0.5 (Everts *et al* 2000). Studies of Mikkola *et al.* (2019) demonstrated the involvement in the development of hip dysplasia of the NOG genes on chromosome 9, and NANOS1 on chromosome 28, and a long intergenic region between NOX3 and ARID1B on chromosome 1. The authors concluded that the strongest candidate genes for hip joint incongruity were NOG and NANOS1, where NOG is a bone and joint developmental gene through Noggin protein which interacts with a group of proteins named Bone Morphogenetic Proteins (BMPs) whose binding to specific receptors helps the development of bones and other tissues (Genetics Home Reference 2020; Mikkola *et al* 2019), while NANOS1 encodes a C₂HC-type Zinc finger 1 protein, mainly associated with reproductive pathology in males but which is able to upregulate a membrane type 1 matrix metalloproteinase (MT1-MMP), a strong collagenolytic factor proved in rheumatoid arthritis with synovial invasion via collagenolysis in humans (Gene Cards 2020; Mikkola *et al* 2019). Regarding the gene locus located between NOX3 and ARID1B genes, its connection with the development of hip dysplasia has not yet been clearly elucidated. However, it appears that the NOX3 gene participates in the processes of degradation of joint cartilage by oxidation processes (being a member of the NADPH oxidases family), while ARID1B is associated with joint laxity. Prompt intervention in hip dysplasia prevents its aggravation by total or partial rupture of the cruciate ligaments or by the development of diseases of the spine, such as disc diseases or degenerative myelopathies. A clear diagnosis is based on clinical signs corroborated with radiological examination. Depending on the degree of deviation from normal, given by the level of

flattening of the femoral head and acetabular cavity, three categories of hip dysplasia are established: mild, moderate, and severe (Schachner and Lopez 2015). Clinical signs mainly appear in the last two categories. The therapeutic approach in hip dysplasia is usually conservative, consisting of the administration of analgesics, anti-inflammatory drugs, joint supplements, reducing the activity of the affected animal, and losing weight. In severe cases, surgical excision of the head and femoral neck helps control the pain associated with this injury (Lippincott 1992; Rawson *et al* 2005). As with the other orthopedic conditions included in this study, the application of physiotherapy procedures as early as possible after surgery, but not earlier than 3-5 days, significantly accelerates the recovery of the animal. In addition to electrostimulation or massage procedures, the active range of assisted motion was applied, which was reviewed to be less painful than climbing stairs (Henea 2020). For the investigated cases, the after surgery recovery in hip dysplasia took place after about 40 physiotherapy sessions.

If hip dysplasia is a condition that mainly affects medium and large dogs, aseptic necrosis of the femoral head is a condition of small dogs, in our study all cases of this kind being found in the Bichon breed. This disorder has been found more frequently in male dogs compared to females, but this could be considered the effect of the small number of samples, as soon as Mickelson *et al* (1981) recognized a non-preferential segregation based on sex, as is the case in humans. The etiology of the disease is not fully known, but some factors such as ischemia resulting from vascular compression or early activity of sex hormones can be considered (reviewed by Henea 2020). Evaluation of the incidence of this disease across different offspring revealed its genetic etiology involving a recessive gene noted with "pd" (recessive monogenic segregation model) (Robinson 2008).

All cases of aseptic necrosis of the femoral head diagnosed in our study were for individuals < 2 years of age. In unfavorable evolutions of the disease, excision of the femoral head and neck is recommended. After surgery recovery based on physiotherapy involved electrostimulation and ultrasound procedures in the muscles of the thigh of the affected limb, which were associated with stretching and treadmill exercises. Compared with hip dysplasia, in aseptic necrosis of the femoral head recovery occurred faster, on average after 20 sessions of physiotherapy. The incidence of coxo-femoral and patella dislocations was equal in our investigated cases, also as an effect of the small number of cases thus diagnosed. Worth noting the presence of patellar dislocation in Bichon, Di Dona *et al.* (2018) reviewing an increased incidence of this condition in small breed dogs, with its medial location. Data on coxo-femoral dislocation showed a non-discriminatory incidence, considering the main cause in its production as traumas resulting from car accidents (Basher *et al* 1986). This fact is confirmed by the case associated with our investigations, a half-breed dog in the age group of 7-10 years, with damage of the joint and adjacent tissues, and distal deviation of the femur. The genetic substrate and the evolution of this disease was studied by Nganvongpanit *et al* (2013), investigating the association of 10 genes with the mechanisms of consecutive development of osteoarthritis. The results obtained by them showed a high correlation between the expression level of nonapoptotic genes (AGG, COL2A1, MMP-3, HAS-1, HAS-2, and TIMP-1), of apoptotic genes (BAX, BCL-2,

CAS-3, CAS-9), and luxation days. The authors concluded that a longer period of joint luxation increases the chances of osteoarthritis developing.

For the cases investigated by us, the physiotherapy procedures completed the therapeutic and surgical intervention, with a satisfactory cure rate after going through at least 20 sessions that included electrostimulation of the affected limb muscles, stretching exercises, ultrasound therapy and exercises on treadmill.

Two cases of rickets, as orthopedic disorders due to nutritional deficiencies, were diagnosed in our study. The affected individuals were two dogs, half-breed, less than 2 years old. Data from the literature show that this condition is related to a disruption of calcium, phosphorus, and / or vitamin D metabolism, but it can be also developed as a nutritional deficiency. Studies in human medicine show the involvement of two groups of genetic factors in the occurrence of rickets: (i) genetic factors associated with disorders of biosynthesis and action of vitamin D: VDDR 1A (vitamin D-dependent rickets type 1A), VDDR 1B (vitamin D-dependent rickets type 1B), VDDR 2A (vitamin D-dependent rickets type 2A), VDDR 2B (vitamin D-dependent rickets type 2B); (ii) factors related to excessive renal phosphate loss (hereditary hypophosphatemic rickets) on the background of the reabsorption deficit related or not to FGF23 (Fibroblast Growth Factor 23, with function in regulating phosphate and vitamin D) (Acar et al 2017). In 2009, LeVine et al. reported a case of rickets in dogs with a common human genetic basis associated with hereditary vitamin D – resistant rickets (HVDRR). Within this pathology is found VDDR - type 2 (vitamins D - dependent rickets type 2), a disorder caused by a resistance of the organ to the active hormone $1\alpha, 25$ – dihydroxyvitamin D₃ or calcitriol, obtained by conversion of 25 – hydroxyvitamin D₃ under the action of renal enzyme 1α – hydroxylase. Deficiency of this enzyme is related to VDDR - type 1. The authors concluded that although in humans HVDRR is an autosomal recessive genetic disorder, they could not establish the mechanism of genetic inheritance in the dog due to the breeder lack of interest in progenitor testing.

In dogs diagnosed with rickets, recovery associated by physiotherapy procedures took place completely after performing an average of 10 sessions that included massage, electrostimulation of the limb muscles and stretching exercises.

Conclusions

2765 dogs and cats were investigated in a period of 21 months, 45 of these (1.55% of the total) being diagnosed with orthopedic conditions that required physiotherapy. Dogs represented the vast majority of cases with orthopedic conditions (82.22%), the difference of 17.78% being for the cats. There were a male prevalence both for dogs and cats in the investigated cases.

Orthopedic disorders that required physiotherapy diagnosed during this study were represented by diseases due to nutritional deficiencies, bone trauma, and joint diseases. In the group of diseases due to nutritional deficiencies we have diagnosed rickets cases represented by two male dogs (4.44%). The diagnosed bone injuries were only fractures (62.22% of all orthopedic cases), most of them affecting the hind limbs (64.29% of all fractures). Joint diseases represented 33.33% of orthopedic disorders, being diagnosed hip dysplasia (46.67% of all orthopedic cases), aseptic necrosis of the femoral head (40% of all

orthopedic cases), coxo-femoral dislocation and patellar dislocation, one case each (6.67% each).

Physiotherapy procedures were associated to the conservative and surgical treatment of orthopedic conditions. Their number of sessions for ensuring a satisfactory recovery was different depending on the type of disease: 20-40, for bone injuries and joint diseases; 20, for coxo-femoral and patella dislocations; 10, for rickets.

References

- Acar S, Demir K, Shi Y. Genetic causes of rickets. *Journal of Clinical Research in Pediatric Endocrinology*. 2017; 9(2):88-105.
- Basher AWP, Walter MC, Newton CD. Coxofemoral luxation in the dog and cat. *Veterinary Surgery*. 1986; 15(5):356-362.
- Colvero AC, da Silva Rauber J, Ripplinger A, Wrzesinski M, Schwab ML, Pigatto A, Ferrarin DA, Mazzanti A. Neurological and orthopedic diseases in dogs and cats submitted to physiotherapy. *Acta Scientiae Veterinariae*. 2020; 48:1760.
- Di Dona F, Della Valle G, Fatone G. Patellar luxation in dogs, review. *Veterinary Medicine: Research and Reports*. 2018; 9:23-32.
- Everts RE, Hazewinkel HAW, Rothuizen J, Van Oost BA. Bone disorders in the dog: A review of modern genetic strategies to find the underlying causes. *Veterinary Quarterly*. 2000; 22(2):63-70.
- Gene Cards. NANOS1, Available at: <https://www.genecards.org/cgi-bin/carddisp.pl?gene=NANOS1>, (Accessed on: 13 th of September 2020).
- Genetics Home Reference. NOG gene, Available at: <https://ghr.nlm.nih.gov/gene/NOG>, (Accessed on: 13 th of September 2020).
- Henea ME. Applications of physiotherapy in musculoskeletal disorders in pet carnivores. "Ion Ionescu de la Brad" Publishing House, Iași. 2020 (in Romanian).
- LeVine DN, Zhon Y, Ghiloni RJ, Fields EL, Birkenheuer AJ, Gookin JL, Roberston ID, Malloy PJ, Feldman D. Hereditary 1,25-Dihydroxyvitamin D-resistant rickets in a Pomeranian dog caused by a novel mutation in the vitamin D receptor gene. *Journal of Veterinary Internal Medicine*. 2009; 23(6):1278-1283.
- Lippincott CL. Femoral head and neck excision in the management of canine hip dysplasia. *Veterinary Clinics of North America: Small Animal Practice*. 1992; 22(3):721-737.
- Loader RT, Todhunter RJ. The demographics of canine hip dysplasia in the United States and Canada. *Journal of Veterinary Medicine*. 2017; Article ID: 5723476.
- Marks D, Comans T, Bisset L, Scuffham PA. Substitution of doctors with physiotherapists in the management of common musculoskeletal disorders: a systematic review. *Physiotherapy*. 2017; 103(4):341-351.
- Mickelson MR, Mccurmin DM, Awbrey BJ, Maynard JA, Martin RK. Legg-Calvé-Perthes disease in dogs: a comparison to human Legg-Calvé-Perthes disease. *Clinical Orthopaedics and Related Research*. 1981; 157:287-300.
- Mikkola L, Holopainen S, Pessa-Morikawa T, Lappalainen AK, Hytönen MK, Lohi H, Iivanainen A. Genetic dissection of canine hip dysplasia phenotypes and osteoarthritis reveals three novel loci. *BMC Genomics*. 2019; 20:1027.
- Nganvongpanit K, Pradit W, Chomdej S. Articular cartilage gene expression after coxofemoral joint luxation in the dog. *Veterinary Medicine International*. 2013; Article ID: 936317.
- Pinna S, Landucci F, Cella V. Pulsed electromagnetic field for the treatment of canine Legg-Calvé-Perthes disease. *Pakistan Veterinary Journal*. 2015; 35(2):245-247.

- Rawson E, Aronsohn MG, Burk RL. Simultaneous bilateral femoral head and neck ostectomy for the treatment of canine hip dysplasia. *Journal of the American Animal Hospital Association*. 2005; 41(3):166-170.
- Robinson R. Legg-Calvé-Perthes disease in dogs: genetic aetiology. *Journal of Small Animal Practice*. 2008; 33(6):275-276.
- Schachner ER, Lopez MJ. Diagnosis, prevention, and management of canine hip dysplasia: a review. *Veterinary Medicine: Research and Reports*. 2015; 6:181-192.
- Simon S, Ganesh MR, Ayyappan S, Rao GD, Suresh Kumar R, Manonmani M, Das BC. Incidence of canine hip dysplasia: a survey study of 272 cases. *Veterinary World*. 2010; 3(5):219-220.

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Citation Henea ME, Grecu M, Grădinaru AC, Solcan G. Incidence, genetic predisposition, and recovery by physiotherapy of orthopedic disorders in dogs and cats. *HVM Bioflux* 2020;12(4):172-179.

Editor Antonia Macarie

Received 7 September 2020

Accepted 8 November 2020

Published Online 16 November 2020

Funding None reported

**Conflicts/
Competing
Interests** None reported