DOI: 10.21005/AAPZ2024.70.2.7

FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2024, 371(70)2, 68–75

Received 4 Sep 2023
Revised 26 Mar 2024
Accepted 8 Apr 2024

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EVALUATING THE IMPACT OF PHYSIOTHERAPY AFTER CRANIAL CRUCIATE LIGAMENT INJURY IN DOGS

Abstract. The study aims to evaluate if rehabilitation in dogs that had suffered from cranial cruciate ligament rupture and underwent tibial plateau levelling osteotomy (TPLO) led to their faster recovery than rehabilitation in non-operated dogs. Medical records were analysed of thirty-one dogs representing nineteen breeds, both sexes, and aged from nine months to fifteen years. The dogs were divided into two groups of small (light) and large (heavy) subjects. A statistical analysis was conducted using the Chi-square test (Chi^2), considering such sources of variation as the body weight (small and large dogs), rehabilitation after the TPLO surgery or rehabilitation with no surgical intervention and the period to restore satisfactory limb function versus the pre-rehabilitation period. The body weight was not the determinant of the dog's regaining fitness after CCL injury regardless of the treatment method. It was discovered that small dogs recovered faster to reach satisfactory performance, and the pre-rehabilitation period after the injury did not affect their performance. Moreover, the time between the injury and the beginning of rehabilitation and between the injury and surgery did not matter for regaining full fitness.

Key words: Canine rehabilitation, The Cranial Cruciate Ligament (CCL), Cranial cruciate ligament injury in dogs.

INTRODUCTION

The Cranial Cruciate Ligament (CCL) plays a crucial role in stabilizing the knee joint in dogs. It is one of the most important ligaments within the knee joint, comparable to the human Anterior Cruciate Ligament (ACL). The cranial cruciate ligament is attached to a fossa on the caudal aspect of the medial side of the lateral femoral condyle.

It courses cranially, medially, and distally across the intercondylar fossa and attaches to the cranial intercondyloid area of the tibia (Arnoczky and Marshall 1977). Its role in dogs involves maintaining the stability of the knee joint during movement. Moreover, it prevents excessive movement of the femur and tibia in relation to each other, ensuring smooth and controlled movement within the joint (Samii et al. 2004; Spinella et al. 2021). During movement, the CCL transmits the forces that act on the dog's hind limb. It protects the knee joint

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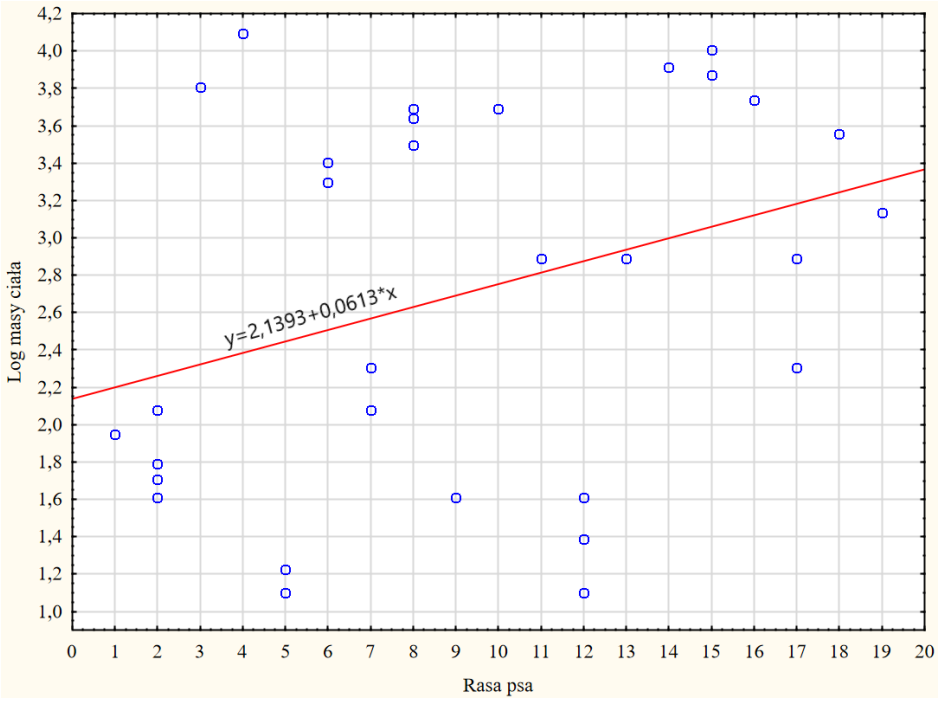
from excessive loads and strains, playing a significant role in maintaining balance during movement, jumping, running, and performing other activities. It is believed that damage to the cranial cruciate ligament is the result of a traumatic event. However, long-term observations have shown that this condition occurs spontaneously due to degeneration of the knee joint under load (Nečas et al. 2000; de Rooster et al. 2006). Damage or rupture of the CCL in a dog can lead to significant impairment of the knee joint function. This manifests as pain, loss of stability, difficulties in movement, and alterations in the animal's gait. It is one of the most common orthopedic injuries in dogs, and its treatment typically requires surgical intervention and rehabilitative therapy to restore knee joint function.

Rehabilitation of the motor system is intended to improve its function after injuries and surgeries and to eliminate the potential resulting pain. Cynological sports such as agility, flyball and frisbee have been developing but they often cause injuries. In such cases, dog owners choose rehabilitation of their pets with reduced motor functions or – in extreme situations – surgical interventions to recover the damaged structures. Rehabilitation improved the comfort of life and mental condition of dogs that had experienced injuries while taking part in competitions; in many cases, it also facilitated coming back to sports and reaching good results again (Monk et al. 2006; Jastrzębska and Wolińska 2015). Nevertheless, injuries do not apply only to sports dogs. Any dog can experience an injury while running, playing, making sharp turns, jumping and skipping etc. They might result from the individual's proneness to injury, inadequate preparation to physical effort, obesity, breed (Duval et al. 1999) or a random event. Achievements in human rehabilitation (Dadej et al. 2013) contributed to a greater interest in animal rehabilitation (Veenman 2006; Millis et al. 2016). The cranial cruciate ligament (CCL) is the structure most often subject to injury in dogs (Fitzpatrick et al. 2010; Rose et al. 2012; Wucherer et al. 2013; Samoy et al. 2015; Dyall and Schmökel 2017). The primary function of the CCL is to limit hyperextension of the joint and the drawer movement and to prevent too much internal rotation of the tibia (Hoffmann et al. 2006). The ligament is a poorly vascularised intra-articular formation that lies outside the synovial membrane area. This limits its regeneration capability in case of post-injury conditions (Arthurs 2017) and the recovery period is long. Therapeutic alternatives include immediate analgesia, surgical intervention and long rehabilitation (Mattila 2012; Schaible et al. 2017). The recovery period to reach satisfactory fitness after the cranial cruciate ligament injury depends on many factors. The literature does not explicitly identify the dominant ones among the breed, body weight, age, dog's activity before the injury and its temperament. In relation to the high costs of surgery aimed to restore the limb's function, many owners decide to limit costs and have their dogs only rehabilitated, hoping that the limb function will be restored without surgery (Canapp 2018; Kirkness 2020). Considering the above, the purpose of the study was to confirm or reject the hypothesis that rehabilitating a dog after a cranial cruciate ligament injury following a TPLO surgery ensures faster recovery than rehabilitation of dogs not subject to surgical intervention.

MATERIAL AND METHODS

The study material covered medical records of thirty-one dogs of nineteen breeds and both sexes provided by an animal rehabilitation clinic in Szczecin. The animals' ages ranged from nine months to fifteen years ($x = 6.9$ years; $\pm s = 4.16$), and their body weights were between 3.0 kg and 60.0 kg ($x = 22.74$ kg; $\pm s = 18.15$). In relation to the high coefficient of variation for the body weight $V = 80.24\%$, the data were transformed. Based on the mean algorithm

of the dogs' body weights, the study population was divided into small (light) dogs (n = 14) whose body weight logarithm was lower and large (heavy) ones (n = 17) with the body weight algorithm higher than the average value (x = 2.70046). Figure 1 presents the distribution of the logarithmised body weight of individuals representing different breeds. The mean body weight of small operated and rehabilitated dogs (n = 8) was 4.42 kg ± 2.51, while the body weight of small and only rehabilitated dogs amounted to 6.58 kg ± 2.20. The group of large operated dogs (n = 7) was characterised by the mean body weight of 39.71 kg ± 11.56, whereas for non-operated rehabilitated dogs (n = 10) it amounted to 34.20 kg ± 14.01 on average.



Body weight log Dog breed

Dog breed: 1 – Schnauzer; 2 – Jack Russel Terrier; 3 – Old German Shepherd; 4 – Landseer; 5 – Spitz 6 – Boxer; 7 – Beagle; 8 – German Shepherd; 9 – Papillon; 10 – Bernese Mountain Dog; 11 – Podenco; 12 – Yorkshire Terrier; 13 – Bavarian Mountain Hound; 14 – Labrador; 15 – Cane Corso; 16 – Labrador-type mix; 17 – Dachshund-type mix; 18 – Irish Setter; 19 – Beagle-type mix.

Fig. 1. Logarithm of the body weights of dogs representing both sexes subjected to rehabilitation

The medical records contained the information that helped divide the animals into two groups, i.e. Group I – subjects after TPLO surgery because of cranial cruciate ligament injury and subjected to rehabilitation (n = 15) and group II – subjects after cranial cruciate ligament injury subjected only to rehabilitation without surgery (n = 16). Dogs in the injury groups I and II were referred to an animal rehabilitation clinic following a consultation with a veterinary orthopaedic surgeon and suggested rehabilitation. Rehabilitation of dogs in group I started between the third and fifth week after surgery.

The medical histories provided by the dog owners suggested that most subjects had moderate physical activity (n = 23), including several longer walks a week and satisfying their basic physiological needs. Only eight subjects enjoyed intensive physical activity involving

long everyday walks and additional physical exercises (e.g. amateur agility training). The rehabilitation course and methods, including treatment intervals, are summarised in Table 1.

Table 1. Rehabilitation progress, including the applied methods

Days of the week	1	2	3	4	5	6	7
Magnetotherapy	+	+	+	+	+	+	–
LLLT	+	+	+	+	+	+	–
Underwater treadmill + kinesiotherapy	+	–	+	–	+	–	–

The rehabilitation covered the following therapeutic procedures: low-level laser therapy (LLLT), hydrotherapy using an underwater treadmill, passive exercises, active exercises (kinesiotherapy), and magnetic field therapy (magnetotherapy) using a disc applicator. After completing the rehabilitation, its effect was evaluated by asking the owner for their subjective opinion on the dog's fitness and by a zoophysiotherapist who examined the passive range of motion (PROM) versus the original condition after the injury; moreover, the dog was assessed in motion and examined with a goniometer and tape measure.

According to the referenced veterinary physiotherapy clinic's experience, dogs after CCL injury achieve satisfactory fitness within 8–12 weeks of rehabilitation. A longer recovery period is costly, and sometimes pet owners decide to discontinue therapy. The period between the injury and the beginning of treatment was adopted as an additional variation. The periods between zero and six months from the injury to surgery or rehabilitation and over six months were taken for the study.

The obtained data were introduced into Statistica v13.1 PL and processed with the Chi-square test considering the sources of variation, e.g. body weight (small and large dogs), rehabilitation after TPLO surgery or rehabilitation without surgical intervention, and the recovery period to reach the satisfactory fitness of the limb versus the pre-rehabilitation condition.

RESULTS AND DISCUSSION

The results of the statistical analysis are summarised in Table 2.

Based on them, the body weight shall not be considered a factor determining the dog's regaining its fitness after the CCL injury, regardless of the treatment procedure (TPLO+REHA and only REHA). Due to the selected treatment, small dogs (body weight log < 2.70046) achieved satisfactory fitness sooner than large dogs, though the values were not considered significant. Moreover, no significant impact of the period preceding the dog's appointment after the injury (six months before or after the injury) was demonstrated, either. Neither the period between the injury and rehabilitation nor between the injury and surgery and the rehabilitation period affected the patient's regaining full fitness. Fitness recovery was confirmed in 90.4% of patients, regardless of when rehabilitation started. Furthermore, 9.6% of patients reached satisfactory fitness within a period longer than the assumed twelve weeks.

According to the literature, time is a significant factor in postoperative rehabilitation. The patients in whom rehabilitation started eight weeks after the TPLO surgery (Romano and Cook 2015) regained full limb function twice faster than in the group of non-rehabilitated dogs. The patients covered by standard post-operative care involving limited mobility and resting were nearly three times more prone to the joint's malfunction in the future. The gen-

eral percentage of perioperative complications was lower in the group undergoing physical and physiotherapy (Monk et al. 2006). The examination of the impact of early intensive postoperative rehabilitation on regaining fitness revealed that physical and physiotherapeutic procedures performed by qualified staff significantly accelerated the increase in the injured limb's muscle weight and the range of motion of the knee joint in patients after TPLO (Marsolais et al. 2002; Millis 2004; Davidson et al. 2005; Monk et al. 2006; Kirby-Shaw et al. 2020). The impact of postoperative fitness improvement methods is also a subject of studies on rehabilitation therapy in humans. Studies on evaluating the impact of rehabilitating patients after cranial cruciate ligament reconstruction provided a positive result. The selected exercises and physical therapy significantly contribute to the final result of regaining fitness, restoring proprioception (de Rooster et al. 2006) and hence supporting the recreation of motion patterns and minimising the force's negative impact on the joint (Dadej et al. 2013). Despite studies suggesting a generally positive impact of rehabilitation, its methods became an area of interest. A positive contribution of low-level laser therapy (LLLT) to the results of treating dogs after TPLO surgery was demonstrated. Improvement in the animal's gait was demonstrated but no impact was confirmed of the method on bone healing after the surgery (Kurach et al. 2015; Renewick et al. 2018). Studies on the magnetic field's (PEMF) impact on bone healing after osteotomy in animals revealed that this type of stimulation accelerated the union of fractured bones and improved the mechanical strength of the bone tissue during its healing (Inoue et al. 2002).

Table 2. Values of the Chi-square test for the applied therapies and recovery period in dogs after CCL injury

No.	Description of the therapy at the analysed sources of variation	Value	Critical area	Significance
1	Rehabilitation of dogs after TPLO and without surgical intervention vs dogs' body weight	0.782	6.635	NS
2	Two-three months' recovery period to reach satisfactory fitness in small dogs vs therapy (TPLO with rehabilitation and only rehabilitation)	0.884	6.635	NS
3	Two-three months' recovery period to reach satisfactory fitness in large dogs vs therapy (TPLO with rehabilitation and only rehabilitation)	0.157	6.635	NS
4	Period between injury and surgery vs rehabilitation result	1.21	6.63	NS
5	Period between injury and beginning of rehabilitation vs its result	5.44	6.63	NS
6	Rehabilitation duration vs result	4.09	13.27	NS
7	TPLO therapy with rehabilitation and only rehabilitation vs dogs' activity	0.571	6.63	NS

No impact of the period between the injury and rehabilitation, between operation and rehabilitation and the rehabilitation's duration on the effect is the study's unexpected result. According to rehabilitation practice, patients in whom fitness-improving methods were implemented sooner after injuries regained full fitness faster than those in whom the injury lasted longer. It has also been found that lightweight and active dogs recover faster after injury, confirming reports by Vasseur (1985), compared to heavier dogs (Table 3).

Table 3. Values of the coefficients of variation for the rehabilitation period and dogs' activity before the injury

Dog's body weight	TPLO + REHA	REHA
Light	0.447	0.612
Heavy	−0.091	−0.279

Persistent and progressing instability of the knee joint caused by cranial cruciate ligament rupture leads to a degenerative disease of the joint and damage to the meniscuses and articular cartilage (Zdeb et al. 2018). Implementing early postoperative rehabilitation, for instance involving manual exercises, prevents articular capsule's contraction, shortening of muscle fibres and formation of synechias.

CONCLUSIONS

1. The body weight was not a determinant of regaining fitness in dogs after CCL injury, regardless of the treatment method.
2. Small dogs reached satisfactory fitness within shorter time periods.
3. The pre-rehabilitation period after the injury did not contribute to reaching satisfactory fitness.
4. The time between the injury and beginning of rehabilitation and between the injury and surgery did not affect reaching full fitness.

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OCENA WPŁYWU FIZJOTERAPII PO USZKODZENIU WIĘZADŁA KRZYŻOWEGO DOCZASZKOWEGO U PSÓW

Streszczenie. Celem pracy było stwierdzenie, czy zastosowana rehabilitacja u psów, u których nastąpiło zerwanie więzadła krzyżowego doczaszkowego i które poddano leczeniu metodą TPLO, usprawnia pacjentów w czasie krótszym niż w przypadku podjęcia rehabilitacji psów nieoperowanych. Przeanalizowano karty medyczne 31 psów 19 ras obojga płci w wieku od 9 miesięcy do 15 lat. Psy podzielono na dwie grupy, psy lekkie i psy ciężkie. Analizę statystyczną przeprowadzono za pomocą testu Chi^2, uwzględniając źródło zmienności, jakim były masa ciała (psy lekkie i psy ciężkie), rehabilitacja po zabiegu TPLO lub rehabilitacja bez interwencji chirurgicznej oraz okres dochodzenia do zadowalającej sprawności kończyny wobec stanu poprzedzającego rehabilitację. Masa ciała nie była czynnikiem determinującym osiągnięcie sprawności psa po urazie CCL bez względu na sposób leczenia. Stwierdzono, że psy lekkie w krótszym czasie dochodziły do zadowalającej sprawności, a okres poprzedzający podjęcie rehabilitacji po urazie nie wpłynął na sprawność psów. Ponadto stwierdzono, że czas od wystąpienia urazu do rozpoczęcia rehabilitacji oraz od urazu do operacji nie miał wpływu na uzyskanie pełnej sprawności.

Słowa kluczowe: rehabilitacja psów, więzadło krzyżowe doczaszkowe, uszkodzenie więzadła krzyżowego doczaszkowego u psów.