



Physiotherapy treatment of musculo-tendinous disorders of the canine shoulder: A clinical study

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ABSTRACT

In veterinary literature, pathologies affecting the shoulder region in dogs are increasingly described, particularly in dogs that practice high-impact sporting activities. Physiotherapy may represent a complementary and supportive treatment to surgery and conservative therapy; however, the supporting scientific evidence is still limited. This study aims to evaluate a multimodal physiotherapy protocol in 25 dogs suffering from shoulder pathologies, examining time and number of sessions required to gain lameness recovery and trying to identify which variables (age, sex, weight, degree of lameness, presence of osteoarthritis, modalities) are able to positively or negatively influence recovery times. Patients received treatment consisting mainly of laser therapy and ultrasound combined with muscle strengthening exercises, hydrotherapy and manual techniques. Data were submitted to a descriptive and statistical analysis to highlight the recovery times and the most important variables. The results showed a mean clinical recovery time of 50 ± 35 days (median: 35 days) with a number of sessions equal to 10 ± 3 sessions (median: 10 sessions). Age, the presence of osteoarthritis, association between Laser and ultrasound therapy and the initial severity of the lameness significantly influenced recovery times. The study highlights the importance of a multimodal physiotherapeutic approach and underlines the need to carry out further large-scale research to standardize treatments and evaluate the impact on return to sporting activity.

Introduction

In recent years, canine shoulder diseases have been frequently described in veterinary literature (Grassato et al., 2019). Lameness of the forelimb in association with localized pain and discomfort during manipulations is commonly observed. Injuries can be acute or chronic, and they may involve different joint components: bone, ligaments, muscles and tendons. In sporting and working dogs a significant higher incidence of shoulder injuries has been observed, with particular reference to dogs practicing high-impact sports such as agility and flyball, in which stress on the muscular, tendon and ligament structures is particularly higher (Hall et al., 2009; Canapp, 2010; Pechette Markley, 2023; Spinella et al., 2023).

An accurate diagnosis requires a correct diagnostic protocol, including: a detailed patient history, physical examination and specific diagnostic imaging tests.

Within the soft tissue injuries of shoulder region, biceps brachii and supraspinatus tendinopathies are more frequently reported (Pechette Markley, 2023), as well as infraspinatus muscle contracture (mainly in

hunting dogs) and medial shoulder instability.

Tendinopathy of the biceps brachii is one of the most described muscle-tendon pathologies of the thoracic limb (Stokes and Dycus, 2021) and usually develops as a result of a recurrent inflammatory process (Gilley et al., 2002). Adult, medium to large-breed dogs are commonly affected, without a particular breed or sex predisposition. Clinical findings include: a chronic, progressive lameness that do not respond to nonsteroidal anti-inflammatory drugs (NSAIDs); a reduction of the range of motion of the scapulohumeral joint affects either flexion or extension (Wernham et al., 2008) and exercise usually leads to a worsening of symptoms (Stokes and Dycus, 2021). Different diagnostic tests may be performed to evoke discomfort on biceps brachii tendon: bicipital test, drawer test, the biceps retraction test (Wernham et al., 2008). Diagnostic ultrasound can characterize the lesion better than radiographic or arthroscopic examination (Bruce et al., 2000).

Supraspinatus tendinopathy is described in medium-large sized dogs with chronic unilateral lameness, often refractory to treatments, which worsens following physical activity (Canapp, 2010; Stokes and Dycus, 2021). On physical examination, dogs experience discomfort or pain

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upon flexion of the shoulder and palpation at the tendon insertion. Hypo/atrophy of the supraspinatus muscle is commonly observed. Concomitant pathologies such as biceps tenosynovitis or medial shoulder instability are also reported (Canapp, 2010).

Infraspinatus muscle contracture generally occurs in medium to large-breeds with an active lifestyle, such as sporting and hunting dogs (Fossum, 2021). Lameness can be acute in the initial phase and arise suddenly following intense activity; subsequently, it is replaced by an abnormal painless gait (Kunkel and Rochat, 2008). The range of motion is reduced and the affected limb presents shoulder abduction, elbow adduction and extrarotation of antibrachium with a particular flip-like action (Kunkel and Rochat, 2008; Stokes and Dycus, 2021). Extension of the shoulder is significantly decreased and atrophy of the infraspinatus muscle is perceived on palpation (Fitch et al., 1999). Diagnostic ultrasound is the first-choice diagnostic technique and also allows to visualize a supraspinatus muscle contracture, often concomitant (Stokes and Dycus, 2021).

Medial shoulder instability (MSS) is a frequent cause of forelimb lameness in medium-large adult dogs, particularly in sporting and working dogs. The lameness depends on the extent of the damage and the structures involved. Muscle hypotrophy, pain during abduction and extension and joint subluxation during abduction may be observed (Canapp, 2010; Stokes and Dycus, 2021).

As in human medicine, physiotherapy has recently become a complementary and supportive therapeutic strategy to surgical and conservative treatments of scapulohumeral joint disorders of the dog (Kromer et al., 2009; Cuesta-Vargas et al., 2013; Becker et al., 2015; Bochenska et al., 2016; Carr et al., 2016; Leeman et al., 2016; Ungru et al., 2018; Owen, 2022; Kern et al., 2023; García et al., 2024). The goals of shoulder rehabilitation are: relieve pain, improve joint mobility and promote muscle strengthening (Marcellin-Little et al., 2007). Chiropractic treatment usually refers to spinal manipulation therapy, although the manipulation of peripheral joints may also be performed, in order to decrease nerve compression and fibrotic tissue stiffness and restore intrinsic spinal reflex activity. At present, the efficacy of this specific manual technique is mostly anecdotal and more clinical trials are needed (Miscioscia and Repac, 2022).

A recent paper on orthopaedics and therapists' opinions on bicipital tenosynovitis treatment has underlined the concept that rehabilitation therapists generally consider the application of modalities such as extracorporeal shockwave therapy, regenerative medicine, and photobiomodulation for this pathological condition (Lane et al., 2023). Lane et al. (2023) reported that the application of therapeutic ultrasound, Pulsed Electromagnetic Fields or acupuncture for treating biceps tendinopathies lacks scientific evidence. Authors observed also the lacks of studies that investigate the variables that could influence the duration and number of physiotherapeutic sessions that lead to the recovery of shoulder lameness.

The aim of this retrospective study was to evaluate the clinical evolution in sports and companion dogs affected by shoulder muscle-tendon disorders and treated with a multimodal physiotherapy protocol. In particular, time and number of sessions requested to achieve lameness recovery was targeted and specific variables (age, sex, weight, degree of lameness, presence of osteoarthritis, modalities) were analyzed in order to confirm the hypothesis that they could affect the physiotherapeutic duration.

Materials and methods

The study was conducted in accordance with European Union Directive 2010/63/EU. The Animal Welfare Body of the University of Bologna provided a positive ethical and scientific opinion on the publication of the data, certifying that the study did not involve animal experimentation but rather clinical veterinary practice (Prot. n. 74251/2025). Treatment consent was obtained from all owners.

Medical records of dogs treated for muscle-tendon injuries of the

shoulder region, admitted to the "Cocoonvet" Physiotherapy Center (Bologna, Italy) from 2022 to 2024 were analyzed.

Inclusion criteria were: a) presence of musculoskeletal pathologies affecting the shoulder region; b) presence of evident clinical symptoms at the time of the clinical examination, such as forelimb lameness (of any degree) and/or pain on palpation of the shoulder; c) diagnostic imaging tests of shoulder lesions pathology, with particular reference to ultrasound and radiographic examination; d) patients submitted to a rehabilitation protocol of at least 21 days and six sessions of duration; e) absence of concomitant metabolic pathologies or cardiovascular and respiratory pathologies that could negatively influence functional recovery.

All incomplete medical records, without periodic follow-up or indication of time of clinical symptoms recovery were excluded.

Breed, age, sex, body weight (kg) and specific physical activity were recorded.

All included patients were submitted to a physical examination in order to identify and/or exclude orthopaedic or neurological problems and to build an appropriate rehabilitation plan. Furthermore, a starting point condition (T0) was identified in order to evaluate improvement or worsening of clinical symptoms.

Static and dynamic clinical evaluations of locomotor system were performed to identify lameness, posture and weight load anomalies. Palpation was then carried at the cervical, thoracic, lumbar and sacral spine, front limb and hind limb. Lameness was graded according to a numerical score ranging from "0" (no detectable lameness) to "4" (severe, non-weight-bearing lameness) (Fossum, 2021). Pain induced by deep palpation of the shoulder and flexion/extension movements was recorded as "Present" or "Absent".

All dogs underwent radiographic and ultrasound examinations before starting the physiotherapy protocol. Anti-inflammatory treatment plan prescribed by referring veterinarians was already completed in all dogs before starting physiotherapy.

Regular monitoring of the patients was carried out, both during clinical checks and through feedback from the owners: in particular the owner was warned to pay attention whether the lameness (if clearly evident) was unchanged, improved or disappeared, and whether the animal appeared more active, less painful or, on the contrary, more worsened after the session. At the beginning of every single physiotherapeutic session, a clinical follow up was performed in which lameness and joint pain were re-evaluated. The dog was considered successfully treated when the lameness score was zero and no pain was detected.

The physiotherapeutic protocol started with six initial sessions of modalities' application: each single session included the application of the therapeutic laser and/or ultrasound modalities. Two sessions a week were recommended to the owner for a total treatment duration of about a month.

The laser therapy was carried out with the LASERVET machine (Massimo Cavedagna srl, Italy) in continuous mode with a power of 2.2–2.6 W and treatment duration of 3.46–2.58 minutes for each area, for a total emission of about 500 joules of energy. Each session lasted approximately ten minutes per area; in any case until a total of 500 J was reached.

Therapeutic ultrasound was conveyed with the O.P.A.F. (Onde Pressorie ad Alta Frequenza, Italian acronym for High Frequency Pressure Weight) type emission technique, which uses high frequency pressure waves (O.P.A.F.® Veterinary Therapy, Fisioline).

The OPAF therapy was performed with a high frequency class E ultrasonic veterinary medical device. This method uses a piezoelectric disk with an emission frequency of 1–3 MHz \pm 5 %, a peak power density of 5 W/cm² and a mean power density of 3 W/cm² to deeply transfer large quantities of mechanical energy (Fisioline, 2023).

After the initial six sessions, aimed at controlling the acute phase of inflammation, therapeutic strengthening exercises were introduced in order to improve the tone and resistance of the shoulder muscles.

Cavaletti poles and cones were first used, initially positioning the poles at the lowest height of 4 cm and gradually increasing at the maximum height of 13 cm for small and medium dogs (< 22 kg) and 23 cm for large dogs (\geq 22 kg). Slow execution of the exercise ensured that the movements were performed completely. Different variations of this exercise were therefore introduced, such as slalom, crawling or following a semicircle path. Standing, sit-to-stand and down-to-stand exercises on proprioceptive boards or Bosu (inflatable unstable surface), give-a-paw and high-five exercises, flexion and extension of the spine were also performed. Some dogs ($n = 5$) presented postural alterations and joint stiffness and they were treated also with chiropractic manipulation and Passive Range of Motion to improve shoulder joint and vertebral mobility.

When patients finally showed no lameness and reduced pain on shoulder manipulation, hydrotherapy was introduced for muscle strengthening. An Idrotech 2000 tank equipped with an underwater treadmill (UWTM) was used. In all patients, training sessions (at least two) were carried out to accustom dogs to the UWTM (10 min). Afterwards, the UWTM protocol consisted of the following phases:

1. Warm Up: 5 minutes of work at low speed, approximately 1–1.5 km/h with water at elbow height.
2. First Sprint: 4 minutes of work at 4.2–4.4 km/h with water at carpal level
3. Recovery: 5 minutes at 1.5 km/h
4. Second Sprint: 4 minutes at 4.2–4.4 km/h with water at carpal level
5. Cool Down: 4 or 5 minutes at 1.5 km/h bringing the water back to elbow level in order to improve the shoulder joint range.

In order to avoid clinical complications, owners were advised to carry out controlled physical activity, avoiding jumping, running, climbing and descending stairs, the sofa or the car. Short walks on a leash were recommended.

Statistical analysis

All the data collected were subjected to a descriptive (mean, \pm standard deviation and median) and analytical statistical analysis. In order to evaluate any differences in terms of the number of sessions necessary for the disappearance of clinical symptoms (lameness and pain on shoulder palpation) calculated in days; the dogs were divided into different groups for the analysis of the following study variables: age (Adults and "Senior"), sex (Male and Female), size based on weight (small-medium sized patients < 22 kg and large sized patients \geq 22 kg), presence or absence of osteoarthritis (OA), addition of OPAF and chiropractic treatment to laser-therapy, comparison of sporting dogs and 'companion' dogs.

The distribution and homoscedasticity of the variables in each group over time were assessed with the Shapiro-Wilk and Levene tests respectively. When the distribution was not normal, the Mann-Whitney test was applied. On the contrary, when the distribution was normal, *t*-test was used where there was equal variance, and Welch's test was used where there was unequal variance.

Furthermore, the number of sessions performed and the healing time (expressed in days) were considered as dependent variables in the multiple regression models to explain which variables could influence the phenomenon studied (Daniel and Cross, 2019).

The distribution and homoscedasticity of the residuals were evaluated through the Shapiro-Wilk test and the Breusch-Pagan test, respectively. Furthermore, the residuals of each model were analyzed through the visualization of ordinary least squares (OLS) plots.

Multicollinearity was assessed through the calculation of the variance inflation factor (VIF) coefficients, values < 3 were considered suitable for the model formulation. The F-test of overall regression significance was then applied to evaluate whether or not the linear regression model provided a better fit to a data set than a model without predictor variables (Daniel and Cross, 2019). Finally, goodness of fit was

assessed through adjusted R^2 (Daniel and Cross, 2019). Multiple regression models for sessions performed and healing time has been reported as supplementary material S1 and S2, respectively.

Statistical analyses were performed using R 4.3.2 (R foundation for statistical computing; Vienna, Austria; <https://www.R-project.org/> accessed on 4th September 2024) using packages rstatix, stats, car, lme4, lmerTest and readxl. A *p* value \leq 0.05 was considered statistically significant.

Results

Thirty-five dogs affected by shoulder tendinopathies were considered for possible study inclusion: ten dogs were excluded because of the lack of initial ultrasound examination ($n = 6$), incomplete medical record ($n = 2$), concomitant disease including a neurological walking deficit and heart disease ($n = 2$). Therefore, a total of 25 dogs were included in the study.

The most represented breeds were: mixed breeds ($n = 11$) and Labrador Retrievers ($n = 4$). Other breeds, all represented by a single case were: Swiss Shepherd, German Shepherd, Apuan Shepherd, Breton, Boxer, Australian Kelpie, Dutch Shepherd, Cane Corso, Border Collie, Rottweiler and Pitbull.

A homogeneous distribution was found between male and female, as 12 were females (7 spayed and 5 intact females) and 13 males (6 neutered and 7 intact males). The two groups (males and females) were compared using two different statistical tests to identify whether there were any differences in number of sessions and healing time. To compare the number of sessions, the *t*-test for the independent variables was used, while the Mann-Whitney test was performed to evaluate the days of treatment. The males group showed a mean value \pm SD of 9.5 ± 2.8 treatment sessions (median: 10 sessions), compared to 11.25 ± 3.6 sessions (median: 12 sessions) for the females. As regards the treatment days variable, the mean value \pm SD was 39 ± 12.5 days (median: 35 days) in males and 63 ± 47 days (median: 35) in the females. Although the apparent difference in mean values between the two groups, no statistically significant differences were detected (Figs. 1 and 2).

As regards the body weight, a mean value \pm SD of 22.7 ± 8.8 kg and a median of 22 kg were reported. On the basis of these values, two groups were therefore identified: 10 dogs weighed less than 22 kg, while in 15 cases the weight was equal to or greater than 22 kg. Therefore, the majority of patients were of medium-large size. The comparison between the two groups revealed no statistically significant differences either in the number of sessions performed ($p = 0.1$) or in the number of days needed to achieve healing ($p = 0.76$).

Regarding the age, the mean value \pm SD was 8.3 ± 4.2 years (median: 9 years). Therefore, also for this variable, patients were divided into two groups. The first group ($n = 11$) included younger adult

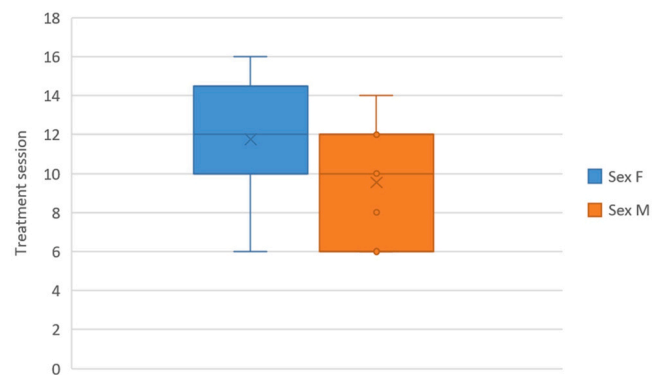


Fig. 1. Number of sessions analysed with the *t*-test for the independent variables. No statistically significant differences were detected between males and females.

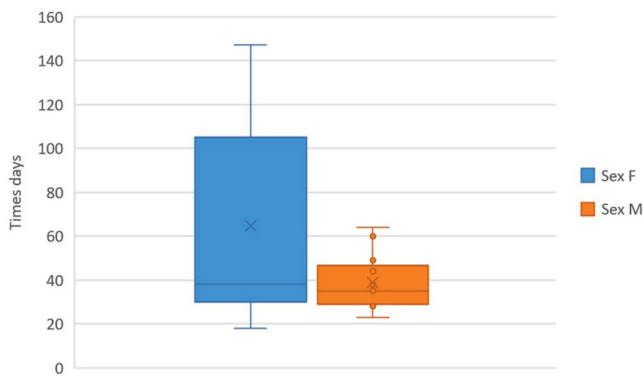


Fig. 2. Days of treatment analysed with the Mann-Whitney test. No statistically significant differences were detected between males and females.

patients, i.e., those under the age of 9 years. The second group (n = 14) included dogs aged nine years or older, therefore considered elderly adults (seniors). Overall, a statistically significant difference has been detected in number of sessions (p = 0.02) between younger adult dogs (mean value ± SD of 8.5 ± 3; median 7) and elderly dogs (mean value ± SD 11.9 ± 2; median 12) (Fig. 3). Conversely, no statistically significant difference was reported regarding clinical recovery time (p = 0.32) between younger adult dogs (mean value ± SD of 43 ± 35 days; median 30 days) and elderly dogs (mean value ± SD of 56 ± 36 days; median 42 days) (Fig. 4).

Five of the 25 dogs included in this study were daily trained sporting dogs: specifically, they practiced hoopers, disc dog, water sports, high-distance running and trekking. One dog regularly practiced both hoopers and water sports. Four dogs were young-adult dogs under the age of 9, while only one was 9 years old and therefore fell into the group of elderly dogs. The breeds represented were Border collie (n = 1), Labrador retriever (n = 1), Australian kelpie (n = 1), Dutch shepherd (n = 1) and mixed breed (n = 1). The sporting dogs required a mean value ± SD of 8.6 ± 3 sessions (median: 7 sessions) and 36 ± 16 days (median: 30 days) to achieve clinical recovery. The statistical comparison between sporting dogs and non-sporting dogs regarding number of session and recovery time did not report any statistically significant difference.

The ultrasound examination reported that the most involved muscles were the m. biceps brachii (n = 22), the m. supraspinatus (n = 13) and the m. infraspinatus (n = 2). Furthermore, a concomitant tendinopathy of the elbow flexor muscles was identified in two dogs. In 7 cases the tendinopathy of the supraspinatus muscle was associate to tendon mineralization. In 12 cases, the ultrasound examination revealed the involvement of more than one tendon; in particular, in 11 dogs there was

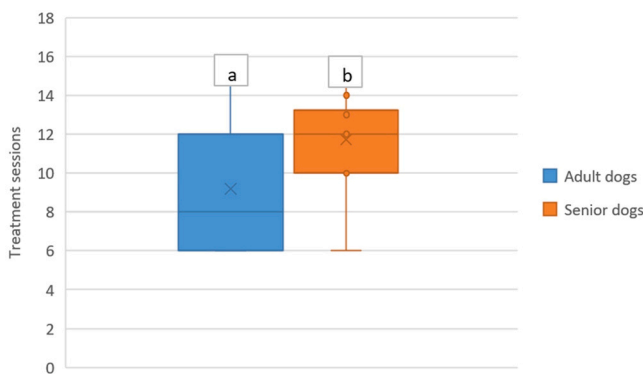


Fig. 3. Comparison between younger adult dogs and elderly dogs for number of sessions of physiotherapy. Different letters (a and b) indicate statistically significant difference (p = 0.02).

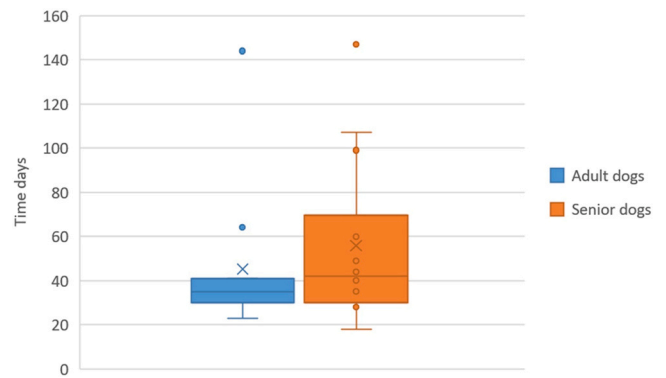


Fig. 4. Comparison between younger adult dogs and elderly dogs for days of physiotherapy. No statistically significant difference was detected.

a concomitant tendinopathy affecting the biceps brachii and supraspinatus, while only one case presented simultaneous involvement of the mm. biceps brachii and infraspinatus. In 11 dogs a concomitant shoulder osteoarthritis was observed (OA-dogs).

The mean value ± SD of clinical recovery period was 50 ± 35 days (median: 35 days) whereas the mean value ± SD of number of sessions was 10 ± 3 (median: 10 sessions).

At the initial clinical examination, all OA-dogs showed pain when mobilizing the shoulder associated with a first-degree lameness (n = 4), a second-degree lameness (n = 5) and a third-degree lameness (n = 2).

Recovery time and number of sessions were analyzed to evaluate whether there was a statistical difference between OA-dogs and non-OA-dogs. In both cases, the Mann-Whitney test revealed statistically significant differences for both variables: p = 0.0029 in the case of the number of sessions and p = 0.012 in the case of clinical healing time. The mean value ± SD of time to achieve clinical recovery in OA-dogs was 71.4 ± 44 days (median: 49 days) versus 33.8 ± 13 days (median: 30 days) in non-OA-dogs. OA-dogs reported a mean value ± SD of number of sessions of 12.8 ± 2 (median: 12 sessions), compared to a mean value ± SD of 8.4 ± 2 (median: 7.5 sessions) in non-OA-dogs.

All 25 dogs included in the study showed a detectable lameness, classified as follows: first degree lameness (n = 15), second degree lameness (n = 7), third degree lameness (n = 2) and fourth degree lameness (n = 1).

In 23 cases pain was present during shoulder mobilization, i.e., following joint extension or flexion.

A multivariate linear regression model was applied in order to better understand which factors could mainly influence parameters such as healing time and number of sessions. Models showed an adjusted R2 of 0.703 and 0.795 for number of session and healing time, respectively.

Considering the number of sessions, the age variable had a statistically significant impact (p = 0.001) and the evaluation of coefficient relatively to age in multivariate regression model reported that for each year of age an increase of 0.35 no. of sessions is necessary to achieve clinical recovery (for example: every three years of age, one more session of rehabilitation is needed to achieve the clinical recovery). Regarding the clinical healing time (days), the variables that showed a statistically significant influence were: age (p = 0.001), the degree of lameness, the presence of OA (p = 0.003) and the use of O.P.A.F. within the therapeutic plan (p = 0.006). Given the evaluation of estimate coefficients by the applied models, the presence of OA and the use of O.P.A.F. appear to be the factors that have the greatest impact on recovery time. Specifically, regression model enlightens that having OA leads to an increase of ~41 days necessary for lameness disappearance, while patients that did not receive both OPAF and laser application could show an increase of clinical healing time of ~35 days. A statistically significant difference (p = 0.016) was observed between dogs with first degree lameness and those with second degree lameness; that is, patients with a

first-degree lameness need less time to heal than those with a second-degree lameness. Furthermore, from the analysis of the Beta coefficient of the multivariate regression model it emerges that the presence of a first-grade lameness decreases the clinical healing time by approximately 20 days, compared to second grade. Differences also exist when comparing patients with first degree lameness and those with third and fourth degree, but differences cannot be correctly compared because of the small number of cases affected by third degree ($n = 2$) and fourth degree ($n = 1$) lameness.

During the rehabilitation process, 10 dogs underwent at least one ultrasound examination. In 8 cases a concomitant improvement of clinical symptoms and ultrasound images was observed.

Discussion

The purpose of this study was to investigate the clinical recovery period of dogs affected by shoulder tendinopathies and treated with a multimodal physiotherapeutic protocol. Twenty-five dogs were included. These patients reported a mean \pm SD clinical recovery period (\pm SD) of 50 (\pm 35) days and a mean \pm SD number of sessions of 10 (\pm 3). The initial hypothesis, that different variables (age, sex, weight, degree of lameness, presence of osteoarthritis, modalities) could influence the duration of treatment and the clinical recovery, was partially confirmed.

Our results were in line with the data reported in the literature (Entani et al., 2021; Kern et al., 2023) as the biceps brachii (80 %) and supraspinatus (52 %) were the most involved muscles; in only two dogs the infraspinatus muscle (8 %) was involved. Furthermore, in 11 patients (44 %), simultaneous involvement of both the biceps brachii and supraspinatus was identified.

Supraspinatus tendinopathy is a less diagnosed cause of forelimb lameness than biceps brachii tendinopathy. Two forms of supraspinatus tendinopathy are reported in dogs: mineralized and non-mineralized (Piras et al., 2023). The breeds most affected by the mineralized form appear to be Labrador Retrievers and Rottweilers (Lafuente et al., 2009; Canapp et al., 2016). In the present study, 13 dogs were affected by supraspinatus tendinopathy, and mineralization was also present in 7 dogs; two of confirmed cases were in Labrador retrievers.

The mean body weight of included dogs was 22 kg and more than half of the patients ($n = 15$) exceeded the mean weight value. Body weight is often considered as one of the factors predisposing the onset of diseases and traumas affecting the musculoskeletal system (Sellon and Little, 2022; Sundby et al., 2022; Kieves et al., 2024). Furthermore, body weight appears to be a potential factor promoting the development of OA (Inkilä et al., 2022; Moritz et al., 2024).

In our study the mean age of the included dogs was 8 years (median 9). However, it is important to note that most of our patients were over 9 years of age, and, considering that the majority of the dogs were medium-large in size, it is possible to state that elderly dogs are the patients most affected by these conditions. Only 4 patients were in an intermediate age range (between 6 and 8 years), while 7 cases were very young patients with ages between 6 months and 5 years. The tendon lesions were therefore mainly observed in elderly dogs or very young dogs, as demonstrated also by Grassato et al. (2019); furthermore, lameness and pain were the clinical symptoms observed in all patients examined.

No differences between the population of males and females were detected, therefore suggesting that sex does not significantly impact the onset of shoulder muscle-tendon diseases.

In recent years, treatment alternatives, time of recovery and return to normal activity are not yet supported by sufficient scientific evidence and the formulation of the therapeutic plan is mainly based on the experience of the veterinarian, since the veterinary literature about these topics is scarce (Henderson et al., 2015; Manfredi and Tomlinson, 2018; Entani et al., 2021).

In our study, considering the first 60 days after diagnosis, 80 % of

patients presented a clinical recovery with no lameness and pain on shoulder manipulation; while, after 120 days 92 % of cases were clinically healed. Only two patients reported more than four months to achieve complete clinical recovery: both dogs were diagnosed with tendinopathy affecting the biceps brachii and supraspinatus muscles associated to OA. Our data are in line with the study conducted by Entani et al. (2021) on 32 agility dogs with a clinical and ultrasonographic diagnosis of shoulder teno-muscular lesions. At 60 days follow up 78 % of patients showed a clinical recovery without ultrasonographic healing; while, after 4 months, 100 % of cases were considered to be sound (Entani et al., 2021). It is important to note that in our study, patients' age ranged from 6 months to 15 years with a mean value \pm SD of 8.3 ± 4 years (median: 9 years); in the study by Entani et al. (2021), the included dogs, being fully active in sport, had a mean value of 5.7 years: it is therefore conceivable that the patients analysed by Entani et al. (2021) were predisposed to a faster and more complete recovery.

Furthermore, Entani et al. (2021) noted that ultrasound healing times have proven to be longer than the disappearance of clinical symptoms. In our study, only ten owners agreed to carry out ultrasound follow up. We did not use ultrasound as a healing parameter but only the clinical improvement was considered (i.e., disappearance of the lameness and absence of pain) since, due to limited specific studies on physiotherapy and rehabilitation programs in canine shoulder pathologies, we based our research protocol mainly on scientific studies and programs applied in human medicine (Marcellin-Little et al., 2007). Shoulder pain in humans is frequently diagnosed in clinical practice with a prevalence of up to 66.7 % (Luime et al., 2004; García et al., 2024) and clinical improvements is widely used to evaluate the positive or negative effects of physiotherapy treatments (Cuesta-Vargas et al., 2013).

As regards to the therapeutic protocol, both in the paper of Entani et al. (2021) and in our study, a multimodal physiotherapy approach was applied. The applied modalities in our study were laser and pulsed ultrasound (High Frequency Pressure Waves - OPAP); in six dogs chiropractic sessions were also performed. Moreover, once the instrumental treatment was concluded, proprioceptive exercises were introduced; UWTD was utilized only in the final part of rehabilitation for muscular tone improvement.

In human medicine, several authors demonstrated that in patients suffering from chronic pathologies affecting the musculoskeletal system, an eight-week treatment with multimodal physiotherapy programs allowed excellent results to be achieved in terms of clinical improvement and pain reduction: an association between manual methods (joint mobilization, massage, stretching, chiropractic) and instrumental methods seems to be a fundamental element of effective management of musculo-skeletal diseases (Kromer et al., 2009; Cuesta-Vargas et al., 2013; Haslerud et al., 2014; García et al., 2024). Furthermore, the association of different instrumental methods allows to act simultaneously on multiple aspects of tissue healing: if laser therapy acts mainly as an anti-inflammatory and pain-reducing tool, the association with therapeutic ultrasound allows faster tissue repair by promoting greater collagen production (Marcellin-Little et al., 2007; Hanks et al., 2015; Henderson et al., 2015).

The procedures described in the literature for OA treatment involve passive mobilization exercises, such as massage and stretching, active exercises to improve balance, proprioception, venous and lymphatic circulation, strengthening exercises and UWTD in order to strengthen the muscles without overloading the joints, thus limiting pain in patients suffering from OA. The most used instrumental methods include low-frequency laser therapy and therapeutic ultrasound (Mortellaro and Miolo, 2004; Mille et al., 2022).

In our study, the therapeutic laser alone was used only in five elderly patients with OA. Since both elderly age and OA were two variables that significantly influenced recovery, it is reasonable to suppose that the use of therapeutic ultrasound would improve recovery in these dogs, if included in a multimodal approach.

Among the statistically significant variables in determining healing time, the concomitant presence of OA and additional use of a multimodal approach (therapeutic ultrasound, laser and chiropractic) appear to be the most relevant. Physiotherapy speeds up post-operative functional recovery times, reduces damage following prolonged limb immobilization, improves joint function by reducing any contractures muscles and by stimulating the trophism of the musculo-tendinous system, allows to manage and reduce pain (Mortellaro and Miolo, 2004).

Experimental studies on the molecular and genetic mechanisms of OA demonstrate that ultrasound therapy can determine complex anti-inflammatory effects, enhancing cellular biogenesis and the development of immunosuppressive cells, which would be useful in inflammatory diseases as OA (Yang et al., 2011). Brosseau et al. (2004) demonstrated that ultrasound treatment of canine joints affected by OA lead to an improvement in the synovial fluid viscosity and increased the range of motion and the muscle mass. Data on the therapeutic efficacy of ultrasound (continuous or pulsed), frequency, energy density and dosing intervals used for OA are still limited (Mille et al., 2022). Therefore, further studies are necessary to investigate the effectiveness and effects of this method in both dogs and humans.

Our study presents some limitations: a first limitation is the small number of patients included; secondly, ultrasound monitoring was also limited to a small number of patients, as not all owners accepted to repeat the imaging examination during treatment.

The sporting dogs included were only five: a greater number would have allowed targeted evaluations for this category of patients and the comparison of recovery times between sports and companion dogs. Furthermore, it would be interesting to evaluate the time required to return to sports competitions and the possible long-term relapses.

Lastly, all dogs were treated with the same physiotherapeutic approach as well as in Entani's study (2021); however, it would be interesting to design a prospective study with standardized follow-up schedules, larger sample groups and a control group of patients not treated with physiotherapy or treated with different modalities in order to establish a baseline with which findings can be compared

Conclusions

The present study suggested that multimodal physiotherapeutic approach (laser, therapeutic ultrasound and chiropractic manipulation), could be very effective and shorten the recovery time. Moreover, age, degree of lameness and presence of osteoarthritis showed a statistically significant influence on clinical recovery, whereas the age variable had a statistically significant impact on the number of physiotherapeutic sessions. The authors believe that in the future could be advisable to conduct a prospective randomized controlled trial that includes an untreated or alternative-therapy control group with defined outcome measures, power analysis, appropriate control arms and standardized follow-up.

CRedit authorship contribution statement

Thomas Dalmonte: Software, Formal analysis, Data curation. **Linda Nundini:** Writing – original draft, Investigation, Data curation. **Simona Valentini:** Writing – review & editing, Visualization. **Iliaria Arena:** Methodology, Investigation, Conceptualization. **Giuseppe Spinella:** Validation, Supervision, Methodology, Conceptualization.

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Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Becker, W., Kowaleski, M.P., McCarthy, J., Blake, C.A., 2015. Extracorporeal shockwave therapy for shoulder lameness in dogs. *JAAHA* 51 (1), 15–19. <https://doi.org/10.5326/jaaha-ms-6175>.
- Bochenska, A., Kaniewska, A., Pomianowski, A., Monowid, T., Reichert, P., Adamiak, Z., 2016. The clinical study of conservative management of bicipital tenosynovitis in working dogs. *Pakistan Veterinary Journal* 36 (1), 112–113.
- Brosseau, L., Welch, V., Wells, G., DeBie, R., Gam, A., Harman, K., Morin, M., Shea, B., Tugwell, P., 2004. Low level laser therapy (classes i, ii and iii) for treating osteoarthritis. *The Cochrane Database of Systematic Reviews* 3. <https://doi.org/10.1002/14651858.CD002046.pub3>.
- Bruce, W.J., Burbidge, H.M., Bray, J.P., Broome, C.J., 2000. Bicipital tendinitis and tenosynovitis in the dog: a study of 15 cases. *NZVetJ* 48 (2), 44–53. <https://doi.org/10.1080/00480169.2000.36157>.
- Canapp, Jr S.O., 2010. Challenging Forelimb Lameness: The Shoulder (Proceedings). November 1. (<https://www.dvm360.com/view/challenging-forelimb-lameness-shoulder-proceedings>) (accessed 10.03.2025).
- Canapp, Jr.S.O., Canapp, D.A., Ibrahim, V., Carr, J.B., Cox, C., Barret, J.B., 2016. The use of adipose-derived progenitor cells and platelet-rich plasma combination for the treatment of supraspinatus tendinopathy in 55 dogs: a retrospective study, 61 *Frontiers in Veterinary Science* 3, 9. <https://doi.org/10.3389/fvets.2016.00061>.
- Carr, B.J., Canapp, S.O., Canapp, D.A., Gamble, L.J., Dycus, D.L., 2016. Adhesive capsulitis in eight dogs: diagnosis and management, 55 *Frontiers in Veterinary Science* 3, 14. <https://doi.org/10.3389/fvets.2016.00055>.
- Cuesta-Vargas, A.L., Gonzalez-Sanchez, M., Casuso-Holgado, M.J., 2013. Effect on health-related quality of life of a multimodal physiotherapy program in patients with chronic musculoskeletal disorders. *Health Qual Life Outcomes* 16 (11), 19. <https://doi.org/10.1186/1477-7525-11-19>.
- Daniel, W.W., Cross, C.L., 2019. *Biostatistics a foundation for analysis in the health sciences*. John Wiley & Sons Inc, New York.
- Entani, M.G., Frantini, A., Dragone, L., Barella, G., De Rensis, F., Spattini, G., 2021. Efficacy of serial ultrasonographic examinations in predicting return to play in agility dogs with shoulder lameness. *Animals* 12 (1), 78. <https://doi.org/10.3390/ani12010078>, 30.
- Fisioline, 2023. O.P.A.F. Teraphy. (<https://fisioline.com/medical/opaf-therapy-2/?lang=en>) (accessed 06 March 2025).
- Fitch, R.B., Jaffe, M.H., Montgomery, R.D., 1999. *Le Lesioni Muscolari Nel Cane*. *Veterinaria* 12 (6), 43–54.
- Fossum, T.W., 2021. *Chirurgia Dei Piccoli Animali*. Edra, Milano.
- García, M.A., Munoz, A.G., Perez, J., Nunez, D.A., Hanned, D., Pruiboom, L., Ledesma, S.N., 2024. Which multimodal physiotherapy treatment is the most effective in people with shoulder pain? a systematic review and meta-analyses, 20 *Healthcare* 12 (12). <https://doi.org/10.3390/healthcare12121234>.
- Gilley, R.S., Wallace, L.J., Hayden, D.W., 2002. Clinical and pathologic analyses of bicipital tenosynovitis in dogs. *The American Journal of Veterinary Research* 63 (3), 402–407. <https://doi.org/10.2460/ajvr.2002.63.402>.
- Grassato, L., Drudi, D., Pinna, S., Valentini, S., Diana, A., Spinella, G., 2019. Shoulder lameness in dogs: preliminary investigation on ultrasonography, signalment and hemato-biochemical findings correlation, 9 *Frontiers in Veterinary Science* 6, 229. <https://doi.org/10.3389/fvets.2019.00229>.
- Hall, C., Trentacosta, N., Percival, M., Levy, I., 2009. A preliminary retrospective survey of injuries occurring in dogs participating in canine agility, 4 *Veterinary and Comparative Orthopaedics and Traumatology* 22, 321–324. <https://doi.org/10.3415/vcot-08-09-0089>.
- Hanks, J., Levine, D., Bockstahler, B., 2015. Physical agent modalities in physical therapy and rehabilitation of small animals. *Veterinary Clinics of North America: Small Animal Practice* 45 (1), 29–44. <https://doi.org/10.1016/j.cvsm.2014.09.002>.
- Haslerud, S., Mangnussen, L.H., Joensen, J., Lopes-Martins, R.A.B., Bjordal, J.M., 2014. The efficacy of low-level laser therapy for shoulder tendinopathy: a systematic review and meta-analysis of randomized controlled trials. *Physiotherapy Research International* 20 (2), 108–125. <https://doi.org/10.1002/pri.1606>.
- Henderson, A.L., Latimer, C., Millis, D.L., 2015. Rehabilitation and physical therapy for selected orthopedic conditions in veterinary patients. *Veterinary Clinics of North America: Small Animal Practice* 45 (1), 91–121. <https://doi.org/10.1016/j.cvsm.2014.09.006>.
- Inkilä, L., Hyytiäinen, H.K., Hielm-Bjorkman, A., Junnila, J., Bergh, A., Bostrom, A., 2022. Part II of finnish agility dog survey: agility-related injuries and risk factors for injury in competition-level agility dogs, 18 *Animals* 12 (3), 227. <https://doi.org/10.3390/ani12030227>.
- Kern, T., Manfredi, J., Tomlinson, J., 2023. Ultrasonographic appearance of supraspinatus and biceps tendinopathy improves in dogs treated with low-intensity extracorporeal shock wave therapy: a retrospective study. *Frontiers in Veterinary Science* 10 (7), 1238513. <https://doi.org/10.3389/fvets.2023.1238513>.
- Kieves, N.R., Shoben, A., Pechette Markley, A., 2024. Risk factors for the development of stifle injuries in canine agility athletes. *Frontiers in Veterinary Science* 11 (14), 1335939. <https://doi.org/10.3389/fvets.2024.1335939>.
- Kromer, T.O., Tautenhahn, U.G., de Bie, R.A., Staal, J.B., Bastiaenen, C.H.J., 2009. Effects of physiotherapy in patients with shoulder impingement syndrome: a systematic review of the literature. *Journal of Rehabilitation Medicine* 41 (11), 870–880. <https://doi.org/10.2340/16501977-0453>.

- Kunkel, K.A., Rochat, M.C.A., 2008. Review of lameness attributable to the shoulder in the dog: part two. *Journal of the American Animal Hospital Association* 44 (4), 163–170. <https://doi.org/10.5326/0440163>.
- Lafuente, P.M., Fransson, B.A., Lincoln, J.D., Martinez, S.A., Gavin, P.R., Lahmers, K.K., Gay, J.M., 2009. Surgical treatment of mineralized and nonmineralized supraspinatus tendinopathy in twenty-four dogs. *Veterinary Surgery* 38 (3), 380–387. <https://doi.org/10.1111/j.1532-950X.2009.00512.x>.
- Lane, D.M., Pfeil, D.V., Kowaleski, M.P., 2023 Nov 1. Synthesis of surgeon and rehabilitation therapist treatment methods of bicipital tenosynovitis in dogs allows development of an initial consensus therapeutic protocol. *AVMA - Journal of the American Veterinary Medical Association* 262 (2), 1–8. <https://doi.org/10.2460/javma.23.08.0461>.
- Leeman, J.J., Shaw, K.K., Mison, M.B., Perry, A., Carr, A., Shultz, R., 2016. Extracorporeal shockwave therapy and therapeutic exercise for supraspinatus and biceps tendinopathies in 29 dogs, 15 *VetRec* 179. <https://doi.org/10.1136/vr.103487>.
- Luime, J., Koes, B., Hendriksen, I., Burdorf, A., Verhagen, A., Miedema, H., Verhaar, J., 2004. Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol* 33 (2), 73–81. <https://doi.org/10.1080/03009740310004667>.
- Manfredi, J., Tomlinson, J., 2018. Return to Sport after Injury: A Web-Based Survey of Owners and Handlers of Agility Dogs, 6 *Vet Comp Orthop Traumatol* 31, 473–478. <https://doi.org/10.1055/s-0038-1670676>.
- Marcellin-Little, D.J., Levine, D., Canapp, S.O., 2007. The canine shoulder: selected disorders and their management with physical therapy. *Veterinary Clinics of North America: Small Animal Practice* 22 (4), 171–182. <https://doi.org/10.1053/j.ctsap.2007.09.006>.
- Mille, M.A., McClement, J., Lauer, S., 2022. Physiotherapeutic Strategies and Their Current Evidence for Canine Osteoarthritis, 21 *Veterinary Science* 10 (1), 2. <https://doi.org/10.3390/vetsci10010002>.
- Miscioscia, E., Repac, J., 2022. Evidence-based complementary and alternative canine orthopedic medicine. *Veterinary Clinics of North America: Small Animal Practice* 52 (4), 925–938. <https://doi.org/10.1016/j.cvsm.2022.02.003>.
- Moritz, R., Klever, J., Reese, S., Meyer-Lindenberg, A., 2024. Prevalence of osteoarthritis in the shoulder, elbow, hip and stifle joints of dogs older than 8 years. *Veterinary Journal* 305, 106132. <https://doi.org/10.1016/j.tvjl.2024.106132>.
- Mortellaro, C.M., Miolo, A., 2004. Approccio medico combinato all'artrosi del cane. *Veterinaria* 18 (3), 9–19.
- Owen, H., 2022. Case study: Treating infraspinatus and supraspinatus trigger points and supraspinatus tendinopathy utilizing piezoelectric shockwave. *Frontiers in Veterinary Science* 9 (26), 943276. <https://doi.org/10.3389/fvets.2022.943276>.
- Pechette Markley, A., 2023. Management of injuries in agility dogs. *Veterinary Clinics of North America: Small Animal Practice* 53 (4), 829–844. <https://doi.org/10.1016/j.cvsm.2023.02.012>.
- Piras, L.A., Olimpo, M., Lafuente, P., Tomba, A., Del Magno, S., Lardone, E., Peirone, B., Mancusi, D., 2023. Surgical treatment of nonmineralized supraspinatus tendinopathy in dogs: a retrospective long-term follow-up, 8 *Animals* 13 (4), 592. <https://doi.org/10.3390/ani13040592>.
- Sellon, D.C., Little, D.J., 2022. Risk factors for cranial cruciate ligament rupture in dogs participating in canine agility, 15 *BMC Veterinary Research* 18 (1), 39. <https://doi.org/10.1186/s12917-022-03146-2>.
- Spinella, G., Valentini, S., Lopedote, M., 2023. Internet-based survey on physical activity and incidence of injury in active working dogs, 16 *Animals* 13 (10). <https://doi.org/10.3390/ani13101647>.
- Stokes, R., Dycus, D., 2021. The shoulder joint and common abnormalities. *Veterinary Clinics of North America: Small Animal Practice* 51 (2), 323–341. <https://doi.org/10.1016/j.cvsm.2020.11.002>.
- Sundby, A.E., Pechette-Markley, A., Shoben, A.B., Kieves, N.R., 2022. Internet survey evaluation of demographic risk factors for injury in canine agility athletes. *Frontiers in Veterinary Science* 9 (8), 869702. <https://doi.org/10.3389/fvets.2022.869702>.
- Unguru, J., Hungerbühler, S., Henninger, W., Klupiec, P., Bödeker, J., Langer, A., Fehr, M., Harms, O., 2018. Diagnosis and treatment of infraspinatus tendon-bursa ossification in a Eurasian dog, 2 *Tierärztlich-Praxis Ausgabe K Kleintiere Heimtiere* 46, 126–132. <https://doi.org/10.15654/TPK-170156>.
- Wernham, B.G.J., Jerram, R.M., Warman, C.G.A., 2008. Bicipital Tenosynovitis in Dogs. *Compendium: Continuing Education for Veterinarians* 30 (10). E8.
- Yang, P., Li, D., Zhang, S., Wu, Q., Tang, J., Huang, L., Liu, W., Xu, X., Chen, S., 2011. Efficacy of ultrasound in the treatment of osteoarthritis of the knee. *Orthopaedic Surgery* 3 (3), 181–187. <https://doi.org/10.1111/j.1757-7861.2011.00144.x>.