2nd ECVSMR Scientific Meeting

Tendinopathies in horses, dogs and humans: lessons learnt when crossing species boundaries

27 February 2021

Proceedings

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Panel Discussion

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PRESIDENTS MESSAGE

Dear Colleagues,

After we had to cancel our congress in Cambridge in 2020 due to the pandemic, we all hoped to be able to meet again live in 2021. However, the pandemic unfortunately makes this impossible for us again this year. However, we are all the more pleased to be able to welcome you to an exciting meeting for which we were able to win top speakers with highly interesting topics. We are also particularly pleased about the numerous scientific abstracts submitted by scientists and our residents. With the VAHL Award we will honour the best project of an ECVSMR resident and thank VAHL for their support and promotion of our residents.

The number of registrations has shown us how great the interest in scientific training is: with almost 1000 registrations from colleagues from all continents of the world, it also shows the importance that sports and rehabilitation medicine has now gained. This is also reflected in the rapid growth of the ECVSMR. It was only in autumn 2017 that our college received its provisional accreditation from the EBVS, and as of today we already count 44 Diplomates and are training 11 residents. We would like to take this opportunity to thank all those who work with so much commitment for our college!

It remains for me to wish you all a wonderful congress, but above all I wish us all that we will get this pandemic under control this year and can look forward to a brighter future.

In this spirit: take good care of yourselves and stay healthy.

Barbara Bockstahler

President ECVSMR

PROGRAMME

Chair: Prof. Roger Smith and Prof. Renate Weller

9.00 - 9.15 Welcome

9.15 - 10.00 Prof. Stephanie Dakin - From horses to humans: inflammation and tendinopathy

10.00 - 10.10 Break

10.10 - 10.55 Prof. Cathy Speed - Human tendinopathies: the art, the science of diagnosis

10.55 – 11.00 Break

11.00 – 12.00 Scientific presentations

11.00 – 11.15 Perrier, P.*, Pfau, Th., Graf von Schweinitz, D. - Effects of treatment with laser therapy of acupoints on upper body movement asymmetry and range of motion in horses

11.15 – 11.30 ter Woort, F.*, Dubois, G., Tansley, G., Didier, M., Franklin, S., Van Erck-Westergren, E. - Validation of an equine fitness tracker: ECG quality and arrhythmia detection

11.30 – 11.45 Eicher, L.D., Markley, A.P., . Sundby, A.E., Shoben, A. and Kieves, N.R.*- Evaluation of Variability in Gait Styles Used by Dogs Completing Weave Poles in Agility Competition and its Effect on Completion of the Obstacle"

11.45 - 12.30 Resident forum

11.45 – 12.00 Mokry, A.*, Bernhard, C., Dumoulin, M., Mievis, A., Pille, F., Delling, U. and Oosterlinck, M. - Retrospective study on clinical findings, treatment details and outcome in foals with rupture of the common digital extensor tendon

12.00 - 12.15 Grosjean, D.*, Van Ryssen, B. and Samoy, Y. - Flexion test applied on dogs: a 10 years retrospective study on lameness clinical cases

12.15 - 12.30 Bogaerts, B.*, Schipper, T., Peelman, P., Van Nieuwerburgh, F., Saunders, J.H. and Broeckx, B.J.G. - DNA methylation alterations in Labrador Retrievers with cranial cruciate ligament rupture: a pilot study.

12.30 – 12.35 VAHL promotional video

12.35 – 13.30 Lunch and Poster presentation

Chair: Zoran Vrbanac

1. Halama, A. , Oliveira, J.M., Filho, S., Qasim, M., Achkar, I.W., Johnson, S.,Suhre, K. and Vinardell, T.*- Establishing a Metabolic Performance Profile for Endurance Racehorses
2. Saitua, A.*, Vida, V., Becero, M., Argüelles, D. and Muñoz, M. - Forelimb accelerations and forces at take-off in vertical jumps at different heights in show jumper horses
3. Aldavó, A.M.*, Smith, R.K.W. - Preliminary descriptive statistics on 54 horses with suspensory ligament branch injuries
4. Becero, M.*, Saitua, A., Argüelles, D. andMuñoz, A. - Total power and velocity before and after application of capacitive resistive electric transfer at 448 kHz in spanishbred dressage horses performing collected, working, medium and extended trot
5. Marescaux, P.*, Martín-Giménez, T., de Blas, I., Cruz, A.M. - Objective assessment of the tempo to improve horse-rider precision in dressage using an extremity mounted inertial measurement unit system
6. Fioretti, M.C.*, Martín-Giménez, T., de Blas, I., Cruz, A.M. - Influence of the rider on movement of dressage horses at collected trot
7. Gruyaert, M.*, Pollard, D. and Dyson, S. - Relative heights of the withers and the tubera sacrale and angulation of the lumbar and pelvic regions in horses with hindlimb proximal suspensory desmopathy, sacroiliac joint region pain and control horses
8. Kieves, N.R.*, Markley, A.P., Shoben, A. - Risk Factors for the Development of Shoulder Injuries in Dogs Competing in Agility
9. Lopedote, M. *, Spinella, G., Iacono, E. - Autologous adipo tissue mesenchymal stem cells (ATMSCs) administration in dog with severe osteoarthritis and arthrosis: a case report
10. Kraljević, A.*, Capak, H., Krsteska, G.J., Šmit, I., Kostešić, P., Bureš, T.; Vrbanac, Z. - Swimming puppy syndrome in a whole litter – a case report

13.30 – 14.00 Prof. Roger Smith – pathogenesis of tendinopathy in horses

14.00 - 14.30 Dr. Jonathan McLellan - Diagnosis of tendinopathy in the equine athlete

14.30 – 14.45 Break

14.45 – 15.45 Dr. Debra Canapp– Whats new in pathogenesis and diagnosis of tendinopathy in the canine athlete

15.45 - 16.30 Panel discussion, Chair: Prof. Roger Smith

16.30 Close

Invited speakers

Professor Cathy Speed

Professor Speed is a Consultant Specialist in Rheumatology, Sport & Exercise Medicine. She is Lead Physician at the Fortius Clinic, London and is Clinical Director of the Centre for Human Performance, Cambridge. She has been Senior Research Associate and Isaac Newton Teaching Fellow in the Department of Medicine, University of Cambridge, and is a substantive Professor of Sports Medicine & Human Performance at Cardiff Metropolitan University, UK. Her clinical interests include human performance across a range of populations and environments, and the use of exercise, lifestyle and performance sciences in disease prevention and management. She also has interests in tendon injuries, bone health in young people, and complex musculoskeletal disorders. Her clinical practice blends her expertise in preventative medicine, rheumatology, sport & exercise and human physiology. Professor Speed has also played a role for over 20 years in high performance sport. She was Senior Physician at the English Institute of Sport (British Olympic sports medical and sciences services) for 15 years, has been acting physician at a number of Olympic and Commonwealth Games and was Chief Medical Officer to the GB Olympic Team at the Athlete Holding Camp for the Beijing Olympics. She has a very active role in teaching, research and education in the fields of Human Performance and Applied Medicine. She has written extensively, in particular on soft tissue injuries. She is a Senior Fellow of the Higher Education Academy, UK, and acted as an Appraiser & Examiner for the Faculty of Sport & Exercise Medicine, UK

Professor Stephanie Dakin PhD BVetMed MRCVS, University of Oxford

Stephanie graduated as a veterinary surgeon in 2003 from the Royal Veterinary College. After undertaking an internship specialising in equine orthopaedics at the Animal Health Trust (Newmarket), she then spent 5 years in practice as an equine veterinary clinician. In 2008, Stephanie commenced a PhD at the RVC researching the role of inflammation in equine tendinopathy, which was successfully completed in 2012. To advance and translate her musculoskeletal research from horses to humans, Stephanie moved to the Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences at the University of Oxford in 2013. Stephanie is currently Associate Professor of Musculoskeletal Sciences, a Versus Arthritis Career Development Fellow and a Fellow of Green Templeton College. She is also Chair of Directors of the Taught MSc in Musculoskeletal Sciences. Stephanie's research focuses on identifying the mechanisms driving chronic inflammation and fibrosis in soft tissue joint disease, with a particular focus on tendinopathy and frozen shoulder. This work aims to discover novel therapeutic strategies to promote resolution of chronic inflammation and fibrosis in musculoskeletal disease.

Dr. Debra Canapp

Debra began her journey in sports medicine and rehabilitation with her certification in canine rehabilitation through the Canine Rehabilitation Institute in Loxahatchee, Florida in 2005. She

has since continued an exclusive career working in small animal sports and rehabilitation medicine. In order to expand the rehabilitative services offered to VOSM's patients, Dr. Canapp became certified in the art of traditional Chinese veterinary medicine and acupuncture by the International Veterinary Acupuncture Society in 2006.

In 2007 she further enhanced VOSM's rehabilitative portfolio when she received her certification in stem cell therapy, a practice that has shown promise in returning our injured canine companions and athletes to their prior function. In 2010-2011, Dr. Canapp pursued studies and advanced training in diagnostic musculoskeletal ultrasound and is currently utilizing this tool, as a leader in the small animal field, diagnostically and therapeutically through ultrasound-guided regenerative medicine injections. In 2012, Dr. Canapp obtained the next level of expertise in her field by becoming board certified in the new American College of Veterinary Sports Medicine and Rehabilitation.

For the past 8 years, Dr. Canapp's exclusive area of interest, clinical work, lecturing and research has revolved around sports medicine and rehabilitation therapy, specifically canine sports-related injury, sport rehabilitation and performance. She has completed advanced courses in canine rehabilitation, hydrotherapy, acupuncture, sports medicine, orthopedics and stem cell therapy. Currently she is practicing sports medicine, acupuncture, musculoskeletal ultrasound and rehabilitation at VOSM.

Dr. Canapp is active in teaching rehabilitation medicine to visiting veterinary students, rehabilitation therapy certification candidates, and veterinarians. She is also engaged in several clinical trials involving sports medicine and rehabilitation and reviews for scientific veterinary journals and grant committees. Dr. Canapp has been published and lectures on the subjects of osteoarthritis, sports medicine, regenerative medicine, musculoskeletal ultrasound and rehabilitation therapy at national and international continuing education meetings. Dr. Debra Canapp, along with her husband, Dr. Sherman Canapp, currently lecture both domestically and abroad on the subjects of orthopedic injuries in the sporting/working dog and the current rehabilitation techniques used to treat them.

Dr Jonathan McLellan BVMS (hons) MRCVS, Diplomate ACVSMR

Dr McLellan grew up working on farms throughout his native Scotland and knew from an early age which path his career would take. He graduated with honors from the University of Glasgow (UK) Veterinary School and undertook a surgical internship working with board certified surgeons at FHB Equine Hospital in Ocala. He is the author of multiple peer-reviewed research

articles and continues to pursue his research interests, specifically training-related injuries and rehabilitation. He is a diplomate of the American College of Veterinary Sports Medicine and Rehabilitation and a Member of the Royal College of Veterinary Surgeons. He has a special interest in challenging lameness diagnostics and the rehabilitation of sports-injuries. He offers consultancy services to FEVA through his business Infield Equine and, outside of his busy work schedule, he spends time with his family and enjoys golf, tennis and soccer (whenever time permits).

Roger K.W. Smith MA VetMB PhD DEO FHEA DipECVSMR DipECVS FRCVS

RCVS and European Specialist in Equine Surgery (Orthopaedics), Large Animal Associate of the European College of Veterinary Diagnostic Imaging, Professor of Equine Orthopaedics Department of Clinical Sciences and Services, The Royal Veterinary College, University of London

Roger Smith is Professor of Equine Orthopaedics at the Royal Veterinary College, London, UK. He qualified as a veterinary surgeon from Cambridge University (UK) in 1987, having obtained a First for his undergraduate degree and a Cambridge Blue at swimming. After 2 years in practice, he returned to academia to undertake further clinical training as a Resident in Equine Studies at the Royal Veterinary College. Following his residency, he undertook a 3 year research project culminating in the award of a PhD for his studies on the extracellular matrix of equine tendon. He remained at the Royal Veterinary College, first as a Lecturer in Equine Surgery, then as Senior Lecturer in Equine Surgery before his appointment as Professor in Equine Orthopaedics in December 2003. He holds the Diploma of Equine Orthopaedics from the Royal College of Veterinary Surgeons and is a Royal College of Veterinary Surgeons Specialist in Equine Surgery. He is a Diplomate of the European Colleges of Veterinary Surgeons and Veterinary Sports Medicine and Rehabilitation, and is also a Large Animal Associate of the European College of Veterinary Diagnostic Imaging. In 2016, he was awarded the Fellowship of the Royal College of Veterinary Surgeons for meritorious contribution to knowledge and was elected to president of the European College of Veterinary Surgeons in July 2017. He divides his time between running a specialist orthopaedic referral service within the Royal Veterinary College, where he is involved in lameness diagnostics, imaging and orthopaedic surgery, and continuing to direct research into equine tendon disease. His principal research interests are understanding the pathogenesis of tendon disease, diagnostics for tendon and ligament disease, and stem cell therapy for tendons in both horses and humans. He is married to a medical doctor and has two sons.

From horses to humans: inflammation in tendinopathy

Professor Stephanie Dakin PhD BVetMed MRCVS PGCert TLHE
NDORMS, University of Oxford

Horses and humans are both highly susceptible to tendon injuries (tendinopathy). In both species, these injuries are a considerable cause of disability and are associated with prolonged rehabilitation and high recurrence rates. The aetiology of tendinopathy is complex and multifactorial, encompassing effects of exercise overload, limb conformation, ageing and genetic factors[1]. Over the past decade, a growing body of scientific evidence supports the contribution of inflammation to the onset and progression of tendon disease[2].
The following pathological features have been identified in tendon tissues collected from equine and human patients:

1) Macrophages show complex activation states, which change with disease stage [1,3,4]
2) Tendon cells show an activated pro-inflammatory phenotype and capacity for 'inflammation memory'[4,5]
3) Tendon cells from patients with chronic tendinopathy show dysregulated resolution responses[6-8]

More recently, single cell RNA sequencing has identified human tendons are comprised of functionally distinct fibroblast, immune and endothelial cell subsets[9], advancing understanding of the phenotypes and function of these cell types in tendon health and disease. Collectively, these discoveries have advanced understanding of the cellular basis of chronic tendinopathy, informing exciting new approaches to address the pathogenic stromal microenvironment in tendon disease[10]. However, there are significant challenges associated with the successful treatment of chronic tendon disease. This is largely attributable to the formation of permanent scar tissue during tendon healing. Therefore, strategies to therapeutically target exercise-induced tendinopathy during earlier stage disease, prior to the development of permanent changes within the tendon are likely to be more successful.

Less is known about inflammation in the context of exercise-induced early tendinopathy, where patients have had symptoms for weeks instead of many months. Tran *et al*. reported increased angiogenesis and anabolic signalling were features of early-stage tendinopathy in samples collected from patients with disease less than 3 months duration[11]. We recently studied the histological features of tendon biopsy samples collected from people with early patellar tendinopathy (<3 months duration). These tissues showed mildly increased cellularity and vascularity and moderate localised expansion of the tendon interfascicular matrix (IFM) compared to biopsies from healthy patellar tendon donors. We also identified markers of fibroblast and macrophage activation were localised to these expanded IFM regions, suggestive of an inflammatory phenotype in early stage disease. Improved understanding of how exercise influences tendon inflammation at the cellular level is critical to develop new therapeutic strategies to target pathogenic cells in early stage disease. This knowledge will also inform the development of physiotherapy regimes to optimise early tendon healing and reduce scar tissue formation.

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Pathogenesis of tendinopathy in horses

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Introduction - the impact of the disease:
Tendon injuries are common in all athletic activities – in both humans and horses. Epidemiological studies, which have looked largely at the incidence of limb injuries sustained in racehorses at racecourses, only show the 'tip of the iceberg'. An ultrasonographic study on National Hunt horses *in training* in the UK showed that almost one quarter of all horses (23%) had evidence of tendon pathology, with some individual yards approaching 50%. This represents a considerable cost to the equine industry both financially and in terms of public awareness.

Pathogenesis
Tendon injuries can arise by intrinsic (overstrain, or displacement) or extrinsic (penetrations, lacerations) damage. The most frequently observed injury is the intrinsic or overstrain injury, predominantly affecting the palmar soft tissue structures which support the metacarpophalangeal (MCP) joint, in particular the superficial digital flexor tendon (SDFT), and the suspensory ligament (SL) but also the accessory ligament of the deep digital flexor tendon (ALDDFT) and the deep digital flexor tendon (DDFT).
Over-strain injury can occur by sudden over-extension of the metacarpophalangeal joint which overcomes the strength of the tendon. However, we now believe that the most common form is following a preceding phase of tendon degeneration. As the SDFT is operating very close to its functional limit, any reduction in functional capacity need only be slight to dramatically increase the risk of clinical tendinopathy.
The preceding tendon degeneration appears to be driven by a combination of ageing and exercise effects. At birth all tendons have a similar composition (the concept of the 'blank' tendon similar to the situation in articular cartilage). However, subsequent mechanical loading, and other anabolic stimuli such as growth factors, act on this naïve matrix to initiate growth and functionally optimal mechanical characteristics. One of the most stark examples of this post-natal adaptation is known as anisotropy where areas under compression (at the level of the metacarpophalangeal joint) develop a more cartilage-like matrix. Differential composition and mechanical properties, characteristic of positional versus weight-bearing tendons, also diverge during growth. Within the tendon fascicular architecture, it appears that much of this change occurs within the endotenon, or interfascicular matrix.
In a variety of experimental exercise studies and post mortem analysis of tendons, the effects of age, function and exercise have been investigated. In young, immature tendon, loading appears to have a stimulatory effect for matrix production while after skeletal maturity this effect appears to be largely lost. In the adult, gross mechanical properties do not differ

significantly with age or exercise, but show a high variance, most likely associated with different exercise histories. However, the collagen fibril crimp angle and length showed a regional reduction in the central core with exercise and age, both acting synergistically, while, in the matrix, regional differences in collagen fibril diameter were seen in long-term exercised older horses, but not in short-term exercised, or younger, horses. The higher proportion of small fibrils in the central region of the long term exercised horses did not correlate with new collagen formation and thus appear to result from disassembly of the larger diameter fibrils. Furthermore, in the centre of the tendon where clinical injury is seen, there was a loss of glycosaminoglycans and COMP in longer-term exercise and older horses.

From the results of these studies it is hypothesised that the mid-metacarpal region of the equine SDFT can adapt to exercise during skeletal development but has limited or no ability to do so after skeletal maturity. The remodelling rates of different matrix proteins in tendon has been calculated which has confirmed that the half-life of the main structural protein in tendon, collagen, is 198 years in the SDFT, while that of the non-collagenous proteins is much less, but still slow, at 2-4 years. After skeletal maturity, the synergistic effect of ageing and exercise causes an inevitable accumulation of microdamage (degeneration) which can not be adequately repaired and predisposes to clinical injury. The clinical signs of subclinical degeneration are minimal, with the significant changes occurring both at a molecular level and likely within specific compartments. The interfascicular matrix shows the greatest evidence for the site of degeneration with the presence of more cleaved proteins and changes in the mechanical properties associated with ageing and which has a key role in determining the mechanical properties of equine digital flexor tendon. Consistent with these changes observed in the tendon matrix, epidemiological studies have repeatedly demonstrated a close association in tendon injury incidence with age in both horses and human athletes.

Mechanisms of age-related degeneration

Our studies have shown high levels of growth factors, especially TGF-β, in young equine tendon, but declining amounts after skeletal maturity. While there is no change in basal cell activity with age in tendon, cell numbers decline and there is ~50% reduction in synthetic response *in vitro* to stimuli such as exogenous growth factors and mechanical load when compared to tenocytes recovered from young SDFT. Interestingly, this reduced cell responsiveness is a property of cells recovered old SDFT but not from the CDET, and hence likely to be a property of weight-bearing tendons which function as a spring for maximal efficiency of locomotion via their energy-storing capabilities. It is interesting to speculate that this has evolved because once the tendon has developed optimal mechanical properties as a spring the addition or removal of matrix will reduce the tendon efficiency (by making it stiffer or more elastic respectively). Furthermore, there is a reduction in gap junction communication in adult SDFT. Thus the absence of an adaptive response in adult tendon is likely to be due to a combination of reduced or absent growth factors, and reduced cellular communication and synthetic ability.

The mechanisms by which degeneration occurs are unclear but possible candidates include the direct damaging effects of repetitive cyclical loading on the matrix or cells, or indirectly via the induction of hyperthermia and cytokine release. We have shown that these indirect effects via cellular activity have the greater effects on tendon matrix *in vitro*. Cyclical loading induced an increase in proteolytic enzyme activity, characteristic of cellular senescence, and a reduction in tendon strength which was negated when the cells were killed, or the enzymes blocked. Thus, greater attention is being focussed currently on the role of cellular senescence and cytokine activity ('tissue inflammation').

Interfering in the development of tendons to reduce the risk of injury

Some of the large variation in the strength of the superficial digital flexor tendon in a population of horses may be due to genetic variation and so improving these traits would be expected to lower the incidence of tendon injury. Certainly, we have been able to demonstrate some polymorphisms associated with equine tendinopathy in racehorses, interestingly involving the same proteins linked to tendinopathy in human Achilles tendinopathy. However, while the concept of using breeding to reduce these risk factors, or modifying training appropriately for affected individuals, is simple, its achievement is considerably more difficult.

Carefully tailored exercise regimes during growth (0-2 years of age) will potentially improve the 'quality' of the tendon and minimise the effects of degeneration induced by training and racing after skeletal maturity (approximately 2 years of age in the horse). These exercise regimes must be within the 'windows of opportunity' of the right time and the right level. Growing tendon is also more susceptible to injury so these 'conditioning' programmes have to induce adaptation suitable for subsequent racing without causing injury. The answers to these questions are not known but, three in vivo studies have investigated the effect of exercise in immature (growing) equine digital flexor tendon.

The first, carried out by the University of Utrecht, involved three different exercise regimes (box rest, box rest with enforced 'sprint' exercise, and pasture exercise) in Warmblood foals from 6 weeks to 5 months of age and the second, performed by the Japan Racing Association, used an increasing amount of treadmill exercise in Thoroughbred foals from 6 weeks to 15 months of age. The third study involved administering over-ground exercise to foals with subsequent entry of the 'conditioned' foals into training and racing (Global Equine Research Alliance (GERA) project). In the latter two studies, exercised foals were compared with control foals given pasture exercise only. In the first study, foals kept at pasture had significantly stronger tendons at 5 months of age than the other two groups largely due to the development of a larger cross-sectional area. The second study documented a significant increase in the rate of increase in cross-sectional area of the superficial digital flexor tendon with treadmill exercise administered for only a small period (five 15 second 'sprints') each day in addition to pasture exercise. In the analysis of the tendon tissue itself, pasture exercise in the first study resulted in the most rapid appearance of the mature population of collagen fibrils while box-rest and box-rest with enforced exercise delayed the onset of this 'adult' phenotype. In the other two experiments, there was little effect of the exercise over pasture exercise on the collagen fibril size and many of the most abundant tendon constituents. It therefore appears that pasture exercise may be optimal for tendon development or that the level of exercise additionally given to the foals was insufficient. Certainly the gambolling activities of foals at pasture would appear to be ideally suited for high strain rate controlled loading of the digital flexor tendons which we believe to be most appropriate for the adaptation of tendon. It may be that both time and intensity 'windows of opportunity' exist above or past which further augmentation of tendon properties can not be achieved.

The initiation of clinical disease

In 'normal' use as a grazing animal, the accumulated micro-damage caused by age and exercise would not be sufficient to provoke clinical tendinopathy. However, within the equine industry we exercise horses in both training and racing/competing which accelerates this process and can weaken the tendon sufficiently to provoke clinical tendinopathy when the normal (or abnormal) loading of the tendon overcomes the resistive capacity of the degenerate tendon. This can happen at any time, including out at pasture, but it is obviously most likely when the horse is loading its tendon maximally. This occurs when the horse is running fastest (hence the best horses are potentially more prone to tendon injury). Ground surface (harder ground increases speed), fatigue causing incoordination (e.g. after longer races, or in unfit horses), jumping, shoeing, and weight are all factors that can increase the peak loading on the tendon and hence are risk factors for tendon injury and potentially also accelerates degeneration. Some of these are rectifiable but others are a consequence of athletic activity and not easily altered.

At the onset of the injury, the severity varies from damage to the interfascicular matrix causing irreversible fibrillar slippage, through individual fibre rupture, to fascicle rupture and finally complete division of the tendon. In the latter case, the paratenon usually remains intact, providing a scaffold for repair and obviating the need for an artificial implant. This damage provokes inflammation (heat, pain, and swelling) which can be detected early with careful palpation. Molecular markers and/or new imaging techniques, based on ultrasound (eg UTC (Ultrasound Tissue Characterisation), or Doppler), MRI or PET, may offer ways of detecting early changes and prevent more severe injury.

Once the tendon fails, the trauma initiates a reparative response which results in the formation of scar tissue which differs from 'normal' tendon in composition, organisation and function. The scar tissue formation is invariably excessive within the SDFT which results in a stiffer tendon once the healing process is completed and this predisposes to re-injury by increasing the strains in adjacent ('transition zone') areas. This process is driven by inflammation. There have been significant advances in recent years in the understanding of these processes, especially with respect to the resolution of inflammation which may be an important factor in the high risk of re-injury. Improving our understanding of the role of inflammation in the mechanisms of degeneration and repair at a molecular level will potentially provide novel therapies and preventative strategies in the future.

Diagnosis of Tendinopathy in the Equine Athlete

Dr Jonathan McLellan BVMS (hons) MRCVS, Diplomate ACVSMR

Florida Equine Veterinary Associates, Ocala, Florida

Tendon injury remains one of the leading causes of wastage in athletic horses of any discipline. Such injuries are a source of frustration because of their insidious onset, extensive healing times, and risk of subsequent reinjury: with no identified treatment protocol ensuring a universally successful outcome. Central to the assessment and treatment of tendon injury is the ability of the clinician to adequately evaluate all stages of the injury from prodromal degeneration, through acute failure, subacute/ reparative phase, and the chronic remodeling phase. Prior to modern imaging modalities, the clinical examination was the main method of evaluating tendon injury and this is remains an extremely useful component of the examination. Over the last 4 decades, grey scale (B mode) ultrasound has become the pivotal imaging modality for evaluating tendon health. There are, however, inadequacies in such standard ultrasound evaluations and, recently, additional techniques or modalities have been employed in search for the 'holy grail' of tendon imaging. This review will focus mainly on the diagnosis of tendinopathy of the metacarpal superficial digital flexor tendon (SDFT) although there is considerable overlap with other tendon and ligament structures.

The Physical examination

Unfortunately, clinical examination is an insensitive method for detecting prodromal signs of impending tendon injury. Astute trainers may observe mild heat or sensitivity on daily palpation or slightly engorged palmar metacarpal vessels associated with early tendonitis, but signs of early degenerative changes are typically lacking until the horse enters the acute injury phase. At that stage, signs of inflammation are present including heat, pain on palpation, a visible profile (bow) which typically occurs in the mid metacarpal region but also fairly commonly in the lower third (low bow) or upper third (high bow). In some cases, transient lameness associated with inflammation may be present but is inconsistent and not well correlated with lesion severity. Severe cases may stand normally but may walk with a 'dropped' fetlock on the affected side due to decreased support due to tendon damage. Examination should include both passive observation and palpation of the area, with the limb both weightbearing and non-weightbearing. Occasionally, subcutaneous oedema, hematomas, cellulitis, or overtight bandages (bandage bows) may appear as 'false' tendonitis but careful palpation of the non-weightbearing limb should allow identification of the thickening of the SDFT which is present in true SDFT injury. Lesions are often unilateral but the contralateral limb should be palpated either to compare to the normal limb of the horse or, to identify that the other limb may be similarly affected. The physical examination becomes less useful once the injury has completed the acute inflammatory phase, although serial evaluations of reduced size on palpation are useful. Daily palpation is also useful once the horse has resumed a rehabilitation exercise program to evaluate if early signs of heat or pain are present, which would indicate further evaluation should be sought.

B mode (black and white) ultrasound

This technology has become the mainstay of confirming tendon injury and parameters for the semi-objective assessment of tendon health have been well documented [1,2]. In the acute phase following injury, the cross sectional area of the tendon often increases and reference ranges of between 0.8-1.3 cmsq have been reported in clinically normal national hunt racehorses [3]. Core lesions of decreased echogenicity and loss of fiber pattern are often apparent either centrally or peripherally within the SDFT and the cross section of these should also be measured. Grading scales have been established for evaluating the echogenicity of core lesions on transverse images and the fiber alignment score (FAS) on longitudinal images [1,4]. Documentation of the injury should include the physical location, which can be in the form of a 7 point 'zonal' system [1] or a metric system measuring distal to the point of the accessory carpal bone (DACB). Whichever method is adopted by the operator, repeatability is the key to useful serial examinations. It should be noted that core lesions represent hematoma formation, thus it is often prudent not to scan immediately following suspicion of an injury but to wait 5 to 7 days to allow a more accurate examination without risk of under-reporting the severity of the lesion. Moreover, not all tendon damage results in a discrete core lesion: it is common to observe a diffuse decrease in echogenicity and FAS associated with an increase in CSA in clinical cases. Whether core lesion or diffuse changes are present, serial assessment of CSA, FAS and echogenicity are all well documented methods to stage the degree of injury and subsequent healing. Initial cross sectional area greater than 20% of the contralateral SDFT is typically indicative of tendonitis in acute cases and, during rehabilitation, enlargement of CSA >10% from the last examination is considered a sign that training is progressing too quickly and exercise should be reduced in intensity by one level, until the image parameters stabilize again [1,5]. B mode ultrasound is cheap, fairly easy to understand and perform, and widely available. It is, however, user dependent and cine loop evaluations are typically preferred over still images to aid image interpretation. Historically, the major shortcoming of the technology is the lack of sensitivity to monitor changes in the healing tendon subsequent to the acute and early regenerative phases of injury. With the exception of subtle changes in FAS, CSA and echogenicity, there is often little discernable difference between serial scans several months after injury and, for this reason, several other modalities and techniques have emerged.

What else is available?

Contrast enhanced imaging

Utilising regular ultrasound technology, it is possible to distinguish between an acute hematoma and a chronic scar by imaging at 10 degrees off-incidence. This is occasionally referred to as "angle contrast enhancement" [6,7]. When a poorly organized scar is present, fibers will be randomly distributed, in contrast to the linear fibers in the surrounding tendon. A slight change in transducer angle takes the normal tendon fibers 'off beam' and they appear hypoechoic. However, the scar will have fibers that remain 'on beam' due to their disorganized distribution and the scar appears as hyperechoic. In contrast, an immature hematoma would appear hypoechoic in both regular imaging and off-beam imaging. In this way, it is possible to approximate the size and chronicity of the lesion in tendons which are many months into the remodeling phase of injury and which may appear normal using regular scanning technique.

This can be performed weight bearing or with the limb non-weight bearing: the usefulness of non-weight bearing ultrasonography has been described elsewhere [7,8]

This technique must not be confused with *true* contrast enhanced ultrasound where microbubbles of air are injected into either the local tendon vasculature or, in the case of intra-thecal injuries, to the tendon sheath [9]. Investigations using contrast enhancement highlight this may be a useful method to evaluate the extend of scar tissue or, when injected into the tendon sheath, to evaluate the extent of lesions which propagate to the tendon margins.

Color flow (Doppler) ultrasound

Healthy tendon has very little discernable bloodflow when viewed using Doppler ultrasound. Acutely injured and proliferating tendon, in contrast, has increased bloodflow in the site of injury due to hematoma formation and subsequent granulation [10]. As tendon heals over time, the blood flow once again subsides [1]. Studies have documented the usefulness of color Doppler ultrasonography to stage the chronicity of lesions [11] and this method may have value in monitoring chronically resolved tendonitis for early stages of increased intratendinous vascular flow, which may pre-empt recurrence of clinical signs. Early reports recommended non-weightbearing longitudinal assessment but other authors have claimed that weightbearing, transverse views are more repeatable [10,12]. When serially evaluating tendon health, it is always advisable to use the method that has greatest repeatability. While this is a potentially useful technique, clinicians must remember that not all 'doppler' is created equally and it is imperative that an operator has an understanding of how any particular machine is set-up to obtain useful, repeatable images. Color Doppler, power Doppler, spectral Doppler are all similar, yet different and not interchangeable terms, and myriad processing settings exist to optimize images. Serial evaluation of tendon injury should, therefore, always use the same machine and algorithms to ensure useful information. It is recommended to set the gain to the maximum level just beneath the noise level (about 85% of maximal gain). A 3-point semi-objective grading scale has been proposed based on the extensiveness of bloodflow [10,12]. This should be considered a useful adjunct modality especially in cases where the chronicity of the lesion is in question: typically cases with 'active' tendonitis, will have greater Doppler flow, relative to chronically affected/ maturing injuries.

Elastography

It has long been known that healed tendon injuries are 'stiffer' than acute injuries. Assessment of this tissue strain has been proposed as a method to determine chronicity of lesions. Compression elastography relies on placing rhythmic external pressure, using the transducer, to create displacement within the tendon structure. This displacement is evaluated by algorithms which then return a colour pattern on the region of interest. Compression elastography has recently been evaluated in the equine and has a reportedly high inter-observer repeatability regarding image interpretation [13]. This is, however, different from inter-operator repeatability which is only moderate as it is dependent on how hard the operator places the transducer and whether a stand-off pad is used. Subsequent to validation in the horse, several studies have been undertaken in clinical cases to 'stage' the chronicity of lesions, with an apparent ability to distinguish lesion stiffness as healing progresses over time [14-16]. This may be useful in the later stages of healing, where comparable grey scale images demonstrated no significance difference over time in the same cases. Another form of elastography, Acoustic Radiation Force Impulse (ARFI), has recently been investigated in the horse with reportedly improved operator repeatability [17] .At the moment, elastography is limited to higher powered console ultrasound machines and further research is required to support widespread clinical use of the technique.

UTC (ultrasound tissue characterization)

In contrast to elastography, although still relying on the generation of a coloured output, UTC assesses stability and continuity of the fiber pattern over the length of a 12cm continuous scan obtained by means of an automated, motorized drive cradle. Images are saved every 0.2mm to create a data block of ‘stacked images’. Various user settings can be configured to process this 3D data and 4 echo types are recognized, each with a unique colour, overlaid onto the black and white image. Images can be assessed longitudinally, transversely, or coronally (a frontal plane view unique to this type of sonography). The technology has been widely adopted in human sports medicine and several publications exist in the equine literature, where UTC has been shown to be sufficiently sensitive to monitor reversible ultrastructural changes over several days post-maximal exercise [18] and also changes over a training season in juvenile Thoroughbreds [19]: although the longterm significance of such changes has not yet been investigated. The technique has both a high interoperator and interobserver repeatability but further clinical research is necessary to determine if it has the potential to predict initial injuries prior to clinical signs. Clinical evaluation in our own practice has been encouraging and we routinely use this technology to direct rehabiliatation regimes, objectively assessing trends of fiber scores with re-evaluations occurring every 30-45 days throughout rehabilitation.

MRI

MRI has been rigorously compared to ultrasonography in human Achilles tendinopathy which is considered comparable to the equine SDFT. In the horse, ultrasound and MRI appear to correlate well in the acute stage of injury [20]. Ultrasound, however, underestimates the cross sectional area of experimental core lesions at 4 weeks compared to MRI, and a hypointense MRI signal at the maximal injury zone persists longer than the ability of standard ultrasound to delineate the core lesion over time[21]. The value of MRI seems, therefore, to be in the later/ chronic stage of SDFT healing, where the presence of a hypointense core lesion signal may indicate a tendon injury which has not yet resolved. While MRI remains the gold standard imaging modality for DDFT imaging in the digit, there is less indication for its use in the metacarpal SDFT due to the high cost of the procedure and increasing availability of other modalities and methods to assess lesion chronicity.

Thermography

IRT, Infrared thermography, has been in clinical practice for over 40 years [22]. Recent improvements in sensor technology have made the procedure more affordable and sensitive across the narrow temperature spectrum required to be clinically useful. Subtle increases in skin surface temperature have been reported as a prodromal finding prior to clinical injury [23] or reinjury, although the technique is user and environment dependent: being affected by the length of hair; ambient temperature; camera distance; bandages; and use of surface medications to name a few variables. This can make interpretation of serial examinations complicated and the technology is best considered a screening tool either prior to injury or during rehabilitation, with any abnormal readings being referred for further confirmatory diagnostic imaging. Other forms of thermography, such as microwave thermography, have also been investigated as possible screening tools for equine SDFT injury [24].

Conclusion

Clinical examination and B mode ultrasound remain the cornerstone of diagnosing equine tendinopathy in the acute phase of injury. Limitations of both techniques in the proliferative and remodeling phases, however, have necessitated the development of techniques and modalities aimed at improving the objective assessment of healing in these later phases of healing. Such techniques will hopefully allow the clinician to tailor each patient's rehabilitation schedule to the health of the tendon at any time point to optimize the balance between appropriate strain versus overstrain during healing. Ultimately, the goal of such advanced imaging is to predict injuries in the pre-clinical stage, when intervention may result in an improved clinical outcome, although further clinical research will be required to validate such claims.

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What's New in Pathogenesis & Diagnosis of Tendinopathy in the Canine Athlete

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Due to the increasing functional age of our canine companions and more importantly, our canine athletes and the overall increase in intense sports and the overuse they bring, there is a growing prevalence of tendinopathies in our canine athletes.Tendinopathy typically refers to tendon overuse injury. This injury naturally occurs in overloaded tendons, which produces pain, exercise intolerance of the muscle/tendon complex and ultimately a decline in function with a tendon that is less tolerant of withstanding recurring tensile load. There is a vague understanding of the underlying biological mechanisms involved in the progression of tendon injuries, despite recent advances in overall tendon research. In addition, there is also continued difficulty in early identification, both in the owner and veterinarian and delayed diagnosis, even with our new community of sports medicine veterinarians. This lecture will explore a summarize current knowledge of triggers, trajectories and diagnosis of tendinopathies. The term “tendinopathy” should be used to describe a broad spectrum of clinical afflictions affecting tendons. Acute and chronically degenerative tendon pathologies are included in this general term all of which present with acute, intermittent, and or persistent pain, impaired performance in training and competitions, and ultimately inflammation and a variety of pathological characteristics consistent with the particular tendon that is injured. Tendinopathies, either in the human, equine or canine world are typically divided into three groups, tenosynovitis, tendinitis and tendinosis, though these terms are frequently misused. Tenosynovitis refers to inflammation of the tendinous sheath only. This term does not incorporate a classic tendinopathy in which inflammation and or degeneration occurs within the tendon fibers. Although tenosynovitis, is usually not misdiagnosed it is often used incorrectly to indicate a true tendinitis. Tendinitis refers to intra-tendinous inflammation with the presence of inflammatory cells noted histologically. Tendinosis refers to chronic degenerative conditions within the intra-substance of the tendon resulting from an accumulation of micro-trauma over time, particularly devoid of current inflammation, though acute tendinitis on chronic tendinosis is not an uncommon finding, therefore complicating the diagnosis.

To complicate things further, the extent of the tendon injury or tissue strain is also usually assigned a grade. Grade 1 tendon strain typically refers to inflammation with very minimal microscopic changes to the tendon fibers. Grade 2 strain refers to both inflammation and damage to the tendon fiber matrix. This grade incorporates injury up to a true partial tear of the tendon and has significant impact in the integrity and strength of the tendon. Grade 2 strains covers both acute injury and chronic fiber changes to the tendon also. Grade 3 tendon strain represents a full tear in the tendon, therefore fully comprising the integrity and classified as a rupture. Future changes are truly needed within this grading system to better define the stages between a grade 1 strain and a full rupture or grade 3 strain as all of the different pathogenesis pathways present differently and should be more representative with additional descriptive terminology to help determine the best treatment based on specific types of injury.

Prior to 2009, tendinopathy was categorized into inflammatory, degenerative or failed healing. Following the failure of reversing/healing of a primary inflammatory state, tendons would progress into a tendinopathy that was considered to be degenerative. Degenerative tendinopathy, at that time was described inconsistently with terms such as hypoxic degeneration, hyaline degeneration and mucoid degeneration, all of which suggest non-reparative, end-stage pathology indicating irreversible, degenerative cell changes and disintegration of the tendon matrix. This degenerative process led to failed healing whereas active cells and increased protein production, was followed by disorganization of the matrix and neovascularization or angiofibroblastic hyperplasia. Chronic tendon overload has been historically associated with failed healing and degeneration, but this exact pathology has also been described when a tendon is unloaded (stress-shielded). It was well documented that unloading a tendon induces this cell and matrix change that was similar to what was seen in an overloaded state. Unloading a tendon also decreases the mechanical integrity of the tendon, though the degeneration seen with unloading has been shown to be mostly reversible.

Despite these mixed explanations of tendon pathology, the prospect that these processes may be connected in a continuum received little thought prior to 2009.

In 2009, a landmark paper, by JL Cook and CR Purdam, "Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy" was published on tendon pathology in the British journal of sports medicine. Up until this time, these categories of tendinopathy lacked explanation as to why these injured tendons presented with such a wide range of diverse elements of pathology. It was in this paper by JL Cook that degenerative pathogenesis of tendon healing was first challenged with a continuum of pathologic events along a tendon's road to tendinopathy. This path of tendon pathology was described in three distinct stages, reactive tendinopathy, tendon disrepair and degenerative tendinopathy, with the understanding that each stage is connected with a constantly changing environment within the tendon.

In 2010, Fu etal also addressed the pathogenesis of tendinopathy in his paper "Deciphering the pathogenesis of tendinopathy: a three-stages process", where he also described tendinopathy as a three-stage process involving injury, failed healing and clinical presentation. He speculated that some of the initial injuries that occur within tendons heal well and that predisposing intrinsic or extrinsic factors may be involved to determine the outcome. Fu also described the injury stage as a "progressive collagenolytic tendon injury" with the failed healing stage relating to prolonged activation and failed resolution of the normal recovery process. It is with this theory of progressive injury, he parallels and supports Cooks continuum model. In conclusion, these the matrix disturbances, increased focal neovascularization and abnormal cytokines contribute to the the end clinical presentations of degenerative tendinopathy, chronic tendon pain and/or eventually failure/rupture.

Ultimately in 2016, JL Cook revisited this new concept with the evidence and research he knew would be required to ultimately support and build this new way of thinking thru the pathogenesis of tendon pathology. The goal of all the continued research to better understand tendon pathogenesis is to guide the development of reliable methods to diagnosis early tendon injury and to finally develop targeted treatments to improve patients' outcomes to return to function.

Humans and dogs often share very similar tendinopathy etiologies. For example, several "degenerative disorders" in the insertion of the supraspinatus tendon have been identified, including rotator cuff tears, calcifying tendonitis or tendinosis, and tendinosis as a result of overuse. Degeneration of the supraspinatus tendon has been suggested to be a factor in the development of rotator cuff tears in humans. Overuse injury has been suggested as the cause of this disorder, and the role of overuse in the pathogenesis has been supported by findings of experimental studies. Histologically, affected tendons contain discontinuous and disorganized collage fibers. Typically, no inflammatory cells are detected. In chronic cases, a proliferative nodule develops which can cause biceps brachii tendon displacement and pain.

In dogs, the most common cause of supraspinatus tendinopathy is over-use due to chronic repetitive activity. Activities such as landing a jump with outstretched forelimbs, quick turns and jump-turn combinations can place the soft tissue structures of the shoulder joint under extreme stress. Repetitive activity puts increased biomechanical load on the tendon, eventually leading to a strain injury. Repeated strain causes disruption of the tendon fibers, creating a core lesion. In chronic cases, two findings may be present: mineralization within the tendon and/or bony remodeling at the point of insertion. These findings in canine tendinopathy support the tendon injury continuum.

The lack of a clear etiology many of times leads to the final diagnosis of "soft tissue injury" with the prescribed treatment regimen of "rest and Non-steroidal anti-inflammatory drugs (NSAIDs) for 14 days". Once the patient is allowed to return to activity, the lameness commonly returns. Many dogs and athletes present with this similar history. It can be difficult to localize the lesion on palpation as many dogs may show increased sensitivity in the shoulder and elbow from referred pain and compensation. To further challenge the veterinarian, it is not uncommon for diagnostics such as radiology to be within normal limits due to the soft tissue nature of these injuries (tendon, ligament, and cartilage). Fortunately, with the availability of advanced diagnostics (arthroscopy, MRI, CT scan, ultrasound, etc.) the definitive diagnosis can be determined, and an appropriate treatment plan created. Depending on the diagnosis (tendon, ligament, cartilage lesions, etc.) treatment options may include regenerative medicine (stem cell therapy, BMAC, PRP, etc.), rehabilitation therapy and in some cases, arthroscopic treatment.

It is important not to forget that the basis behind all early action and proper/precise diagnosis is a good history, a good, non-sedated orthopedic physical exam, lameness assessment involving many gaits and dynamic engagements, baseline radiographs, and a solid sports medicine knowledge base that will allow the practitioner to build a story and accurate rule out list from the above diagnostic baseline.

A retrospective study by Canapp S, et al evaluated 327 dogs with SST. In this study, medical records (2006 to 2013) were reviewed for history, signalment, prior treatments, physical examination findings, diagnostic imaging and arthroscopic findings, concurrent shoulder and elbow pathologies, and treatments performed. Results of the study showed dogs ages ranged from 4 months to 14 years (average 6.5 years; median 6 years). Performance and sporting dogs were 39.4% of the population, with 58.1% of them being agility dogs. Pain was elicited on palpation of the supraspinatus tendon in 49.3% of dogs. Shoulder radiographs in 283 dogs showed mineralisation in 13% of cases. MRI of the shoulder was performed in 31 cases and revealed findings indicative of ST, including hyperintensity of signal on T1 weighted image (or "spin-lattice") and Short T1 Inversion Recovery (STIR) sequences of the supraspinatus tendon at its insertion on the greater tubercle and mineralisation of the supraspinatus tendon. Common ultrasonographic findings included increased tendon size (76%), irregular fibre pattern (74%), and non-homogeneous echogenicity (92.5%). The most common findings on shoulder arthroscopy were supraspinatus bulge (82.2%) and subscapularis pathology (62.4%). Elbow pathology was recorded in 54.5% of dogs. Treatment outcomes showed 74.6% of dogs failed to respond to non-steroidal anti-inflammatory drugs (NSAID) and 40.8% failed to respond to rehabilitation. In conclusion, these findings suggest concurrent shoulder and/or elbow pathology is not uncommon in dogs with SST. Further, SST often fails to respond to NSAID therapy and rehabilitation therapy.

The continued quest for an economical, repeatable, reliable method to detect early tendinopathy is essential to revolutionize the tendinopathy prevention, treatments and outcomes.

Diagnostic ultrasound of the musculoskeletal system in both human and equine medicine has been a significant component of sports medicine and orthopedics for decades. It has been shown to be the superior diagnostic tool for diagnosing and treating tendons, ligaments and muscle injuries. In numerous, older research projects, initial ultrasound tendinopathy studies used lower powered probes which provided unclear, hard to read images. Many of these used were 7.5 MHz linear transducer probes because of its flat application surface and its resolving power. Currently, higher resolution transducers between 10-20 MHz linear probes are the most popular used. These are the same scanning probes used on our elite human athletes to pinpoint and diagnose their injuries in order to secure a proper treatment and rehabilitation plan. With the development of these higher resolution probes, diagnostic musculoskeletal ultrasound in small animals is becoming more common and a very, welcomed tool in the world of canine sports medicine, soft tissue injury and rehabilitation. Diagnostic ultrasound can offer a quick, non-invasive way to diagnose soft tissue injuries and accessible way to monitor them during treatment and the rehabilitation process. Currently diagnostic ultrasound can also assist in confirming that tendon injuries have healed and determine the appropriate time to return to sport/function. Advantages of using ultrasound in the diagnosis and monitoring of treatment of small animal soft tissue injuries include the ability to visualize soft tissues in great detail and certain structures in dynamic form during movement, which may aid practitioners in their complete evaluation and ultimate decision on outcome of treatment and rehabilitation. In addition, most exams do not require anesthesia and it is offered at a lower cost than MRI, which allows for easy and more frequent/affordable rechecks. The ability to monitor musculoskeletal healing more closely offers the practitioner and therapist the ability to change programs to accommodate the precise stage of healing. Unfortunately, some disadvantages include a steep learning curve for the veterinary practitioner, which has limited the availability of adequately trained musculoskeletal ultrasound practitioners. This also reveals a drawback of all diagnostic ultrasound, which is most ultrasound imaging, especially musculoskeletal, is operator dependent and particularly difficult in acquiring and analyzing the images correctly. This emphasizes the importance of finding a veterinary practitioner that is experienced, in addition to being well trained, in the art of musculoskeletal ultrasound, well versed in orthopedics and sports medicine, and preferably board certified in either radiology or the American College of Veterinary Sports Medicine and Rehabilitation (ACVSMR).

Diagnostic musculoskeletal ultrasound may be used to definitively diagnose a wide range of tendinopathies in canines. Because it can be challenging to identify the lesion, it is imperative to have someone experienced in small animal musculoskeletal ultrasonography perform the ultrasound. We prefer diagnostic ultrasound to MRI because we are able to perform serial evaluations without sedating the patient and it is much less costly. Throughout treatment, serial ultrasound rechecks allow us to objectively measure response to treatment and best customize the patient's rehabilitation therapy program. Most injuries in the area of the shoulder, carpus, iliopsoas, stifle or tarsal area can often be classified and differentiated by diagnostic ultrasound. These injuries often include disruption of the tendon fibers, older injuries with scar tissue or calcification, or inflammation/active tendonitis. This capability to accurately identify early changes within the tendon and specifically, the precise damage that has occurred, ultimately helps to determine to correct course of treatment and avoids the common misconception of "rest and NSAIDS" should fix the problem. Often times this type of "non-precise" treatment to soft tissues injuries only end up delaying the correct course of treatment and ultimately getting the patient back to normal daily function or sport and competition.

Classifying these injuries using ultrasound findings to determine if a grade 1, 2 or 3 strain or sprain is important to determine the most effective course of treatment, albeit rehabilitation modalities only, orthobiologics ultrasound guided injections or surgery. In 2020, W. Matthews, etal published an ultrasound specific article pertaining to methods to stage Achilles tendinopathy. This is the first study to use the continuum model of tendon pathology in cultivating an USI-based criteria to diagnose tendinopathy. In this study, tendon thickness, vascularity and echogenicity were all measured and analyzed with strong intra-rater and inter - rater results. The data supports and promotes further work using ultrasound as the diagnostic modality of choice when tendinopathy is present.

Current common objective measurements for diagnosing and monitoring improvement in ultrasound-guided injections for soft tissue injuries include area of tendon, stress ratio using elastography, and fine flow doppler to detect neovascularity. Up and coming objective measurement areas in MSK ultrasound include patient side tomographic visualization, computerized ultrasound tissue characterization (UTC) and quantification of tissue architecture and integrity of the collagenous matrix thru determination of echo type fiber pattern. It's important to look for appropriate healing indications such as reduction in swelling, reduction in thickening of tendons and ligaments, increased blood supply, increased normal tissue regeneration, improvement in fiber type and eventually resolution of the primary injury.

In conclusion, diagnostic musculoskeletal ultrasound is a continuing evolution of an indispensable tool for diagnosing tendinopathy and supporting further data gathering in the continuum model of tendon pathology, both of which have an important place in tendinopathies in our canine athletes.

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Sports Medicine and Animal Rehabilitation

Guest Editor:

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Deadline for manuscript submissions:
30 June 2022

Message from the Guest Editor

Dear Colleagues,

Mobility issues are a well known problem in veterinary medicine. Detecting these problems, finding a proper solution for them and getting these animals back to work can be very challenging, especially in the world of canine and equine athletics.

The scope of this Special Issue is to publish advances in Sports Medicine and Rehabilitation research, both in the Small Animal, as in the Equine field. This includes novel techniques for lameness detection on the one hand and the results of specific rehabilitation schemes and techniques on the other.

Specific tests and therapies developed for professional sports often find their way to the general population as well, but this goes both ways! So if any of you feel that you have something to share that might revolutionize the diagnosis and/or treatment of mobility problems, this is the Special Issue to publish it in.

Dr. Yves Samoy
Guest Editor

Abstracts

Effects of treatment with laser therapy of acupoints on upper body movement asymmetry and range of motion in horses

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Background: The intent of this study was to evaluate the effects of laser therapy on movement symmetry and range of motion following its application on acupoints in horses.
Materials and methods: In this double blinded crossover study, 11 acupoints were located by two certified acupuncturists in 6 unsound (lameness ≤2/10) horses and then treated by a certified physiotherapist with either a sham or a therapeutic laser (Companion CTC, Delaware, US, Wavelength: 980/810 nm, pulse rate 1168Hz, aperture size: 0.5 cm^2, Output power: 1.2W, Dose: 20J per acupoint, 40J/cm^2), at day 0, 1 and 3 of the study. Ten movement asymmetry (HDmin, HDmax, HDup, WDmin, WDmax, WDup, PDmin, PDmax, PDup and HHD) and thirty range of motion parameters (DV, ML, R, P and H for the Poll, withers, T13, L1, sacral and tail region) were recorded both before and after treatment, using objective inertial sensor gait analysis. The results were compared against day of treatment, laser applied (sham or treatment) and exercise condition, using a mixed linear model ($P<0.05$).
Results: No significant difference was found in movement symmetry or range of motion following the use of therapeutic laser on specific acupoints. There were some significant values obtained when comparing range of motion parameters to day of study (P values between <0.001 and 0.043) and to exercise condition (P values between <0.001 and 0.016), but not in relation to the type of laser (sham or real).
Conclusion: Low level laser therapy did not show any significant improvements in movement asymmetry or range of motion in treated horses.

Abbreviations:
HDmin: Head minimum difference
HDmax: Head maximum difference
HDup: Head upward amplitude difference
WDmin: Withers minimum difference
WDmax: Withers maximum difference
WDup: Withers upward amplitude difference
PDmin: Withers minimum difference
PDmax: Withers maximum difference
PDup: Poll upward amplitude difference
HHD: Hip hike difference
DV: Dorsoventral
ML: Mediolateral
R: Roll
P: Pitch
H: Heading

Validation of an equine fitness tracker: ECG quality and arrhythmia detection

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Background: Exercising arrhythmias have gathered much interest, in the context of what is considered normal, potential performance limitation and sudden cardiac death. One limitation to large-scale studies in horses is the availability of an easily applicable, owner-friendly device, to allow recording large numbers of high-quality exercising electrocardiograms (ECGs). The objective of this study is to assess the ability of a novel wearable ECG device (Equimetre) to detect abnormalities in comparison to a widely used telemetric ECG device (Televet).

Methods: Simultaneous ECGs were recorded with both systems on 49 healthy racehorses during exercise. Both ECGs were evaluated using Kubios premium software. Quality of recording was assessed subjectively and quantified. Arrhythmia detection (yes/no) and arrhythmia classification (sinus, atrial or ventricular) were compared using a Cohen's Kappa coefficient.

Results: Eleven horses were excluded due to a non-diagnostic ECG (2 from the wearable device, 8 from the Televet and 1 from both). Some artefact (<10%) was present in 6 and 16 ECGs of the wearable and Televet devices respectively, with 32 and 22 ECGs respectively considered excellent quality. Of the 38 horses, 4 had sinus arrhythmia, 9 had atrial premature complexes and 2 had ventricular premature complexes. There was excellent agreement between the wearable and Televet ECG devices (k=0.97) and arrhythmia classification (K=0.87).

Conclusion: This wearable device (Equimetre) provides a reliable exercising ECG for arrhythmia detection although in occasional cases rhythm classification can be challenging. This creates an opportunity for future large-scale investigations into the occurrence of arrhythmias in normal horses, the effect on performance and a possible link with sudden cardiac death.

Evaluation of Variability in Gait Styles Used by Dogs Completing Weave Poles in Agility Competition and its Effect on Completion of the Obstacle

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Introduction: The aim of this study was to evaluate and define paw placement patterns for dogs completing weave poles during canine agility trials. Secondary objectives were to determine the most efficient running style, determine completion percentages, and provide a basis for future studies to evaluate long-term implications of variants in weave style and predisposition to injury. The authors hypothesized that single-stepping would decrease ground contact time and yield significantly faster run times.

Methods & Materials: Competition video was reviewed as dogs attempted completion of weave poles and a survey was completed. Specific data collected included: competition class and height, dog demographic data, successful completion of the weave poles, front limb and rear limb paw placement styles, and time of completion.

Results: Of the 1,377 runs that were reviewed, weave style could be determined for 1,364 (99%). The most popular weave style was front feet single-stepping (FFSS) 518 (38%), followed by front feet hopping (30%) and front feet double stepping (23%). Weave times were significantly faster for competitors using FFSS when compared to other gait styles.

Discussion: The results of this study indicated that dogs do use distinct gait styles when running weave pole obstacles, with FFSS yielding significantly faster run times compared to other gaits. We suspect this to be due to shorter contact time required when stepping with a single foot. Additional evaluation is needed to confirm this. Clear classification of running styles will allow future studies to evaluate different stresses on joints such as the shoulder between varying gait styles.

Retrospective study on clinical findings, treatment details and outcome in foals with rupture of the common digital extensor tendon

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Background: Rupture of the common digital extensor tendon (CDET) in foals is sparsely documented in literature.

Materials and methods: Retrospective study of foals with CDET rupture presented to the University of Ghent and Hannover (2009-2020). History, clinical examination, and treatment details were retrieved from clinical records, and outcome was based on telephone questionnaire with the owner.

Results: The study sample included 20 foals, mostly Warmbloods (15/20), with an equal distribution between male and female foals. Median age on admission was 7.5 days (range 1–21). Fourteen foals presented with concurrent flexural deformity, including one carpal, 11 fetlock, and two combined carpal and fetlock deformities. In two cases, no treatment was performed for financial reasons. Treatment included medical support, immobilization (bandage/splint/cast, tailored to the individual case and stage of healing), and box rest. The foals were hospitalized for a median of 27.5 days (range 7–76); all foals survived to discharge. Follow-up was obtained for 18 horses. Three horses were euthanized for reasons unrelated to CDET rupture. Six foals with short-term follow-up (median 6.5 months, range 4–8) presented excellent functional and cosmetic outcome, whereas 5/9 foals with long-term follow-up (median 33 months, range 12–90) were reported to have functional limitations in performance, which owners attributed to CDET rupture.

Conclusions: CDET rupture is a rare condition often requiring prolonged veterinary care, especially in cases with concurrent flexural deformity. Unexpectedly, long-term follow-up revealed functional issues in a substantial proportion of foals. The potential association with reduced athletic performance requires further investigation.

Flexion test applied on dogs: a 10 years retrospective study on lameness clinical cases

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Scientific background: The flexion test (FT) is a clinical tool commonly used to assess lameness in horses. This test is part of the palpatory examination and is easy to perform in routine orthopedic examination. Similar to horses, this tool can also be applied to dogs.

Material and methods: A FT is defined by the flexion of a dog's joint for one minute before walking 15 meters on a hard surface. The FT is considered positive if the lameness increased after its application. Selection criteria for this study are dogs undergoing a FT in our orthopedic department between 2009 and 2020, presence of medical imaging records, arthroscopic results and clinical diagnosis. Over 1576 patients' files are collected for this research and sorted in a Microsoft Excel® file.

Results: This study is still ongoing at the time of submission of the abstract. Preliminary results reveal 66% of true positive FT outcome against 7% of true negatives. A rate of 20% of false negatives outcome is measured, when 7% were false positives.

Conclusion: These preliminary results reveal a majority of reliable response to the canine FT. This tool can be considered as a useful tool for canine orthopedic examination.

DNA methylation alterations in Labrador Retrievers with cranial cruciate ligament rupture: a pilot study

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Background: Cranial cruciate ligament rupture (CCLR) is an orthopaedic disease with a high overall prevalence in dogs, especially in large breeds. Currently, there is no phenotypical screening method that can predict a dog's susceptibility to CCLR at a young age. Since some breeds seem to be more "at risk" for CCLR than others, this disease is assumed to have an underlying genetic component. Genetic studies have yielded no clinical applicable results so far and therefore, we seek an alternative approach in this pilot study on DNA methylation as a potential epigenetic marker.

Materials and methods: Blood samples of 14 Labrador Retrievers with CCLR and 14 matching controls of the same breed, sex and highly similar age were investigated with MBD-sequencing.

Results: In total, 4,507,735 regions of 500bp were examined for differential methylation associated with the case/control status. Five differentially methylated loci were detected, with two of these located in introns of protein-coding genes (*PLB1* and *FAT3*), one intergenic, one in the intron of a non-coding RNA and one in the promotor region of a second non-coding RNA. While the overlap between cases and controls was substantial based on individual loci, a principal component analysis based on all five loci revealed a close to perfect separation of cases and controls.

Conclusion: Overall, these results provide an interesting starting point to further investigate the potential of blood-based epigenetic markers associated with CCLR susceptibility.

POSTERS

Establishing a Metabolic Performance Profile for Endurance Racehorses

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Background: Endurance sport refers to any kind of competition in which participants stamina is tested to its limits. Although participating animals are frequently eliminated from the race, due to various health conditions, there is currently no parameter estimating the animal fitness to compete. Our objectives were to provide an in-depth characterization of metabolic consequences of endurance racing as well as to establish a metabolic performance profile for those animals.

Materials and Methods: We monitored the performance of 47 horses of Arabian and half-Arabian breed in endurance races at a distance ranging from 80 km to 120 km. Blood samples were collected, and plasma samples were obtained before (at the time of the vet check) and after the competition (within 30 minutes after the end of the race or upon elimination) and analyzed using a broad non-targeted metabolomics platform.

Results: We measured 792 metabolites, out of which 417 showed significant alterations between before and after the race. The race triggered alterations in molecules involved in branch chain amino acid (BCAA), histidine, lysine and taurine metabolism, as well as α-, β- and ω-oxidation of fatty acids. We further identified metabolic differences between the animals who completed the race and those who didn't, in particular in molecules related to BCAA and omega-6 fatty acid metabolism. We identified a set of six metabolite predictors (imidazole propionate, pipecolate, ethylmalonate, 2R-3R-dihydroxybutyrate, β-hydroxy-isovalerate and X-25455) of animal performance in endurance competition; the resulting model had an area under a receiver operating characteristic (AUC) of 0.92 [95% CI: 0.85 – 0.98].

Conclusion: This study provides an in-depth characterization of metabolic alterations induced in horses participating in endurance races. Furthermore, we showed the feasibility of identifying potential metabolic signatures as predictors of animal performance in endurance competition.

Forelimb accelerations and forces at take-off in vertical jumps at different heights in show jumper horses

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Background: Accelerations and forces in fore-and hindlimbs are determinant of the ability to clear an obstacle. The current study describes forelimb accelerations and forces at take-off in horses clearing different jump heights in order to establish reference values that would help to follow-up training in jumpers.

Material and methods: Thirteen adult jumpers (body weight between 480-560 Kg; withers' height between: 164-175 cm) performed two vertical jumps of 50 cm, two of 70 cm, two of 100 cm, and two of 120 cm with their rider. Horses were equipped with a triaxial accelerometer (Equimetrix) fixed in the sternal region. Data were not normally distributed, and a Friedman test was used to assess differences between jump heights.

Results: Mean values for forelimb accelerations at take-off were 2.36, 2.67, 2.68 and 3.12 g for the four jump heights (50, 70, 100 and 120 cm). This acceleration was significantly lower in jumps of 50 cm compared to 100 and 120 cm. Mean forces in the forelimb at take-off were 6259, 7203, 7597 and 8865 N at the four heights, with values significantly higher for jumps of 70, 100 and 120 cm compared to 50 cm. Jump duration was longer in jumps of 120 cm (0.51 s) compared to 50 (0.39 s), 70 (0.41 s) and 100 cm (0.43 s).

Conclusion: The current research provides values that could be used in these horses during training to assess their improvement along a sportive season. The relationship between these values and performance in competition requires further studies.

Preliminary descriptive statistics on 54 horses with suspensory ligament branch injuries

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Background: This retrospective case series aimed to identify factors that may influence the outcome of suspensory ligament branch (SLbr) injuries, with the central hypothesis that hindlimb SLbr injury had improved prognosis compared to forelimbs.

Materials and methods: Cases from a single institution were included if lameness had been localised to the SLbr with diagnostic analgesia, confirmed by ultrasonography, and with no concomitant injuries.

Results: 61 SLbr injuries were recorded from 54 patients with almost equal distribution between forelimbs (48%) and hindlimbs (52%). 65% were examined within 3 months of injury and 35% were chronic. Focal pain on palpation and swelling was present in 59% and 61% of cases respectively. Low 4-point regional analgesia was positive in 97% of cases, while abaxial sesamoid analgesia was positive in only 5/12 (43%) and intraarticular analgesia of the fetlock joint in only 2/15 cases (13%). From 42 cases with follow-up, 79% returned to their previous level, although 3 injured other structures subsequently. 7% improved but did not return to their previous activity, and 14% were unsuccessful. The outcome was worse in hindlimbs (73%) compared to forelimbs (85%). 22/27 acute cases (82%) returned to performance versus 14/19 chronic cases (73%). The nature of the ultrasonographic lesion had no effect on outcome. Treatment was varied but 20/22 (91%) of those treated conservatively were successful compared to 13/20 (65%) receiving additional treatments (PRP, stem cell therapy, shockwave, and/or arthroscopy).

Conclusions: SLbr injuries have a fair prognosis but additional treatments may not offer as beneficial outcome as anticipated.

Total power and velocity before and after application of capacitive resistive electric transfer at 448 kHz in Spanish-bred dressage horses performing collected, working, medium and extended trot

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Background: Capacitive resistive electric transfer (CRET), a radiofrequency at 448 kHz, increased superficial and deep temperature, hastened elimination of metabolic and inflammatory (sub)products and enhanced sport performance in human athletes. The current research compares the effect of CRET in velocity (V) and total muscle power (TP) in dressage horses, applied before a training reprise.

Materials and methods: Eight Spanish-bred dressage horses with similar training level performed two reprises: before (control) and 24 h after a session of CRET. The order of the reprises was randomly distributed and a washing-out of 20 days between them was allowed. CRET was applied in right and left sides of neck, shoulder, back and croup for 50 min. Velocity and TP values were obtained with a triaxial accelerometer (Equimetrix) fixed in the sternal region. Only trotting data are reported. A Wilcoxon- matched-pairs test assessed the differences between control and CRET.

Results: CRET resulted in a reduction in velocity at extended trot (mean±standard deviation: 4.06±0.34 at control; 3.74±0.41 m/s after CRET; $p=0.011$). Velocity at collected, working and medium trot were not significantly different between reprises. TP increased after CRET in the medium trot (19.51±5.33, control vs. 23.39±6.14 after CRET; $p=0.00001$) and in the extended trot (30.26±7.73, control vs. 33.33±8.55 after CRET; $p=0.0001$). Although a trend ($p<0.2$) towards increased TP at collected and working trot was observed after CRET, statistical significance was not reached.

Conclusions: CRET is a useful technique to enhance muscle power at medium and extended trot. The effects of these change on performance in competitions deserved further investigations.

Objective assessment of the tempo to improve horse-rider precision in dressage using an extremity mounted inertial measurement unit system

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Background: In dressage, the tempo is defined as the number of times per minute that the limbs contact the ground, and its regularity is an important criteria towards final scoring. This parameter is trained and can be automatically measured in real-time using extremity mounted inertial measurement units (IMUs). The aim of this study was to evaluate horse-rider partnership precision at walk, trot and canter and their variations (medium and extended).

Materials and Methods: Six pairs of horse-rider of the Spanish National Dressage's Technification Plan were included. Optimal pair tempo was determined during training with a metronome and compared with the pair's tempo during a competition simulation by means of an IMU system. Differences and precision in tempo between training and competition simulation were analyzed.

Results: The average tempo determined by IMUs was 108 bpm and 109 bpm in medium and extended walk respectively, 160 bpm and 164 bpm in medium and extended trot respectively and 98 bpm and 100 bpm in medium and extended canter respectively. The pairs showed greater precision at canter (-1% medium and +1% extended) than walk (+3.7% medium and +4.3% extended) and trot (+1.7% medium and +3.6% extended). Differences in tempo between training and competition simulation were significantly different ($p < 0.05$) among the different pairs.

Conclusions: The use of extremity mounted IMUs allows an accurate and automatic assessment of the tempo providing immediate and objective information to the rider to facilitate greater precision in the execution of the required exercises.

Influence of the rider on movement of dressage horses at collected trot

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Background: Rider effect on kinematics of dressage horses requires further investigation. The aim of this study was to determine the rider's influence on dressage horses' movements.

Material and Methods: Thirteen (9.6±2.45 years) Spanish crossbred horses were included. Horses were non-lame as previously determined by veterinary assessment and a gait analysis commercial system (Equinosis® Q with Lameness Locator® software). Horses were equipped with a previously tested system including 8 extremity mounted inertial measurement units (IMUs). They were trotted in straight line with an average speed of 3.36 ± 0.30 m/s, ridden and on hand. Data were collected in triplicate. Mean±SEM of temporal (n=15) and spatial (n=17) variables were analyzed using a one-way repeated measures ANOVA.

Results: Stride duration (s) was significantly longer (p=0.003) in ridden horses (0.73s±0.01s) than on hand (0.69s±0.00s). Left (p=0.016) and right (p=0.023) forelimb phasing (%) and maximal left (p=0.001) and right (p=0.014) knee flexion angle occurred earlier in the stride in ridden horses. Range of motion (ROM) of the left (p=0.009) and right (p=0.027) carpi and left (p=0.002) and right (p=0.001) radii were greater in ridden horses, while the ROM of the left (p=0.015) and right (p=0.030) tibia was smaller in those horses.

Conclusion: The use of IMUs can be useful as a monitoring tool to detect areas of possible improvements in the quality of movement of dressage horses.

Relative heights of the withers and the tubera sacrale and angulation of the lumbar and pelvic regions in adult sportshorses with hindlimb proximal suspensory desmopathy, sacroiliac joint region pain and control horses

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Introduction: In non-lame horses, the tubera sacrale (TS) are usually lower than or, less commonly, equal in height to the withers. Thoracolumbosacral, pelvic and hindlimb posture/conformation may be influenced by musculoskeletal pain, and development and function of epaxial, pelvic and abdominal muscles.
Objectives: To determine the relative heights of the withers and TS and the pelvic and lumbar angles in horses with forelimb and hindlimb lameness.

Methodology: Retrospective clinical study over 12 months. Horses (n=193) presented for lameness or poor performance with a conclusive diagnosis based on abolition of clinical signs by diagnostic anaesthesia and imaging were included. Polystyrene hemispheres were adhered to the withers, TS and tubera ischiadica (TI). Lateral photographs were acquired with each horse standing squarely, with the head and neck in a neutral position, the metatarsal regions vertical, aligned with the TI. Relative heights of the withers and TS were determined using ImageJ. A line from the TS to the TI relative to the horizontal defined the pelvic angle. A line from the TS tangential to the lumbar region relative to the horizontal defined the lumbar angle.

Results: The withers height was ≥ TS in 138/193 (71.5%) horses; the withers were lower than the TS in 55/193 (28.5%) horses. Pelvic and lumbar angles ranged from 20.0-42.7° (mean 28.9°, SD 3.4°) and 6.3-18.7° (mean 12.2°, SD 2.3°), respectively. No association between measurements and injury groups was determined.

Conclusions: Withers height was < TS in a larger proportion of lame horses compared with published data for non-lame horses.

Risk Factors for the Development of Shoulder Injuries in Dogs Competing in Agility

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Introduction: Shoulder injuries are reported to be the most common injury sustained by dogs participating in agility. We aimed to determine potential risk factors for shoulder injuries in canine agility athletes. We hypothesized that earlier contact training and weave training, along with competition at the national or international level would lead to increased risk of developing a shoulder injury, while later onset of training would decrease the risk for developing a shoulder injury.

Methods & Materials: An internet-based survey was conducted. Logistic regression was used to estimate the association between shoulder injury history and the variables of interest.

Results: Surveys were completed for 4,197 dogs. Shoulder injuries were reported in 12.5% of dogs. In the final model seven variables were independently associated with odds of shoulder injury. Variables associated with increased odds of shoulder injury included, older dogs, heavier dogs (OR: 1.13 per 1 year older and OR: 1.07 per 10 pounds heavier, respectively), having radiographs made to assess growth plate closure (OR: 1.39), competing at the national and international level (OR: 1.28 and 1.51 respectively), increased average runs per trial day, and starting tunnel training between 10-12 months old.

Discussion: Competing at a national and international level was associated with increased odds of reporting a shoulder injury, as was having radiographs made to assess for growth plate closure. There was no observed association between trained contact behaviors, weave training method, or age of starting training and injury history. It appears that competitiveness of the handler may be the most important factor for developing shoulder injuries, rather than training of particular obstacles.

Autologous adipo tissue mesenchymal stem cells (ATMSCs) administration in dog with severe osteoarthritis and arthrosis: a case report

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Background: We report the clinical case log of a 7 years old male Labrador dog, (43kg b.w.) with a complex orthopaedic history and treated with intra- articular administration of autologous ATMSCs. The dog, at the age of 5 years, was surgically treated three times for a right CCLR because of implant failure. A 2/5 lameness and reduced PROM of left elbow, ataxia and lumbarsacral tract when extending the hind-limbs, were observed. A T3-L3 spinal cord compression was also suspected. Physioteraphy (laser, massage, passive exercises, UWTM) in association of FANS was administered for reducing pain and improving ROM. Weight gain and worsening of osteoarthritis produced an increasing of lameness of left elbow and autologous ATMSCs administration was proposed to the owner.

Materials and methods: Cells were isolated from autologous falciform ligament, maintained in culture until passage 3 resulted CD90, CD44 positive, CD34 negative and were able to differentiate in mesoderm lineages. 5x106 cells/1 ml of plasma were ultrasound guided injected. Weight, muscle circumference and ROM of the left elbow was assessed. Two day spost-injection, local inflammation was observed in the site of administration; no other adverse reactions were detected. One month after injection the limb was not swollen or painful, and no progress of the inflammatory process was revealed. A second ATMSCs administration, in left elbow and in right stifle, was prescribed 9 months later, after observation severe lameness for arthrosis.

Results: All clinical monitored data were improved.

Conclusion: Results suggests that ATMSCs could be considered as effective and safe long-term therapy for canine osteoarthrosis.

Swimming puppy syndrome in a whole litter – a case report

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Background: Swimming Puppy Syndrome (SPS) is an uncommon disease that occurs in the first weeks of life. Breeds predisposed to SPS include brachiocephalic and chondrodystrophic dogs. There is no sex predilection. Clinically manifested by the inability to walk, the limbs are permanently positioned laterally, in abduction. The prognosis is good if therapy is started within the first 3 to 4 weeks of age. Treatment approach of SPS should focus on physical therapy, bandaging, and improvement of environmental conditions.

Materials and Methods: A whole litter of mixed-breed puppies, three females and one male were presented in sternal recumbency at the age of 4 weeks. The pups were non-weight bearing with the limbs in abduction and only capable of swimming-like movements. In half of the puppies, all four limbs were affected; the other half had only the forelimbs affected. Neurological exam showed no abnormalities. Radiographic examination displayed mild changes on sternum anatomy in two puppies. Measurements of the frontosagittal and vertebral index did not exhibit deviations concurrent with *pectus excavatum.* No signs of pneumonia were observed. Physical therapy was started immediately, and consisted of massage, joint passive range of motion, standing, and proprioceptive exercises. Bandages were placed on the legs to prevent abduction.

Results: The first puppy became ambulatory on the fourth day. The last puppy took thirteen days from the beginning of physical therapy to make the first independent steps.

Conclusion: The application of physical therapy as well as bandaging resulted in the recovery of the entire litter.