

What is Veterinary Sports Medicine and Rehabilitation (VSMR)?

- Branch of medicine that focuses on the neuro-musculoskeletal (MSK) system
 - Anything causing painful, restricted, paretic or otherwise altered movement
 - Can be the primary therapy, or to augment surgical approaches
 - Most recent specialty to be recognized by the AVMA – Diplomate American College of Veterinary Sports Medicine and Rehabilitation (DACVSMR)
 - Can specialize in either horse or canine focus (or become double boarded in both)
 - Many ACVSMRs also boarded in ACVS or ECVS
- **Sports Medicine side:**
 - Focused on diagnosing (and treating as indicated) the cause of MSK dysfunction (paresis, lameness, reduced performance or flexibility)
 - Equally useful in all dogs – not just sporting or competitive dogs
 - A key diagnostic tool is a meticulous and detailed physical examination of neurologic status, muscles (assessing tone, bulk, tenderness, reactivity, flexibility, etc.), bones, joints (active/passive range of motion (ROM), stability, pain, fibrosis, end feel, etc.)
 - Other diagnostic tools include imaging (radiographs, ultrasound, CT, MRI), diagnostic joint blocks, muscle biopsies, etc.
 - Some conditions are treated surgically, whereas others are better resolved through non-surgical means. Most muscular and tendinous issues are best resolved with sports medicine techniques.
- **Rehabilitation side:**
 - Recovery from:
 - **Surgery** (particularly orthopedic or neuro Sx, but could be from any major surgery – abdominal, mass removal etc.)
 - **Neurologic insult** (IVDD, FCE, DM, brachial plexus avulsion, etc.)
 - **Trauma** (any significant physical trauma, parturition, recovery from debilitating infectious disease, etc.)
 - or **any combination** of the 3
 - Palliative care of chronic conditions (geriatric care, non-Sx paresis, OA, etc.)
 - Multimodal management of chronic pain conditions

What is the clinical evidence to support VSMR?

Rehabilitation therapy focuses on returning normal mobility to affected limbs... but why is that so important?

Effects of Immobilization on Bone

- Non-weight bearing decreases cortical and cancellous thickness, as well as density and stiffness
 - These effects are more profound in young dogs and can cause permanently reduced bone mineral content and mass
- Most rapid bone loss happens in the 1st 6 weeks, but can continue for 32 weeks, at which point half of bone mass can be lost
 - It can take 12 weeks to undo the bone loss caused by 6 weeks of immobilization, but the loss at 32 weeks can only be partially undone

Effects of exercise on bone

- Deposition occurs with weight bearing exercise and in areas of bone subjected to increased muscle force (Wolff's law)

Effects of immobilization on joints

- Proliferation of IA fibrofatty tissue and adhesions within synovial folds
- decreased synovial fluid production and circulation, with decreased proteoglycan synthesis and increased water content
- Thinning and softening of articular cartilage, with atrophy of subchondral bone and chondrocyte death giving rise to increased cartilage deformation under loading
- Weakened ligament insertions sites, weakened surrounding musculature, and regional osteoporosis, resulting in reduced load to failure and energy absorbing ability
- Potential for irreversible damage

Effects of exercise on joints

- High stress and repeated loading immediately after immobilization may damage cartilage
- It takes 3 weeks of mobilization to undo the damage caused by 6 weeks of immobilization, up to 50 weeks to undo the damage caused by 11 weeks of immobilization, and >15wk immobilization may not allow complete recovery
- Leed's hypothesis – basically Wolfe's law for cartilage; that it will adapt to forces to which it is regularly exposed
- Goldilocks zone:

- Mild to moderate training – running 4-20km/d increases cartilage stiffness, thickness and proteoglycan content
- Young dogs running 40km/d for a year or older dogs 1hr/d has adverse effects

Effects of immobilization on muscle

- Rapid atrophy during 1st week, more gradual after that
- Muscle strength can be lost even without a reduction in muscle mass
- 3 weeks immobilization caused a 30% decrease of blood flow to musculotendinous junction – it took 8 weeks of exercise to undo this effect
- Joint pain, effusion or immobilization causes reduced strength and activity in the surrounding muscle (**reflex inhibition**)

Effects of exercise on muscle

- In humans, 10min of standing offsets deleterious effects of bed rest by 25%; resistance exercise offsets by 50%
- Most immobilization changes are reversible, but starting earlier gives better response
- Older dogs not respond as well
- Recovery proportionate to training (but often takes twice as long to reverse)
- Eccentric contractions activate satellite cells more than concentric
- NSAIDs may delay muscle regrowth

Effects of immobilization on tendons and ligaments

- Even if joint movement is allowed, stress deprivation rapidly reduces the mechanical properties of tendon/ligaments, especially at the bone interface, and this process can take a year to reverse
- Ligament is affected more than tendon, with reduced cross-sectional area, fibril disorganization, and decreased collagen mass
- Immobilization causes decreased oxygen consumption of tendon/ligaments, which is already low to start with

Effects of exercise on tendons and ligaments

- It takes 18wks of exercise to reverse 6 weeks of immobilization and up to 1yr at bone-tendon interfaces
- Training increases tend/ligament strength 10-15%

Clinical Research

- A number of meta-analytic studies have been performed on the human side, with the majority demonstrating positive benefit for various specific conditions – conditions that also exist in canines.

- Research is lacking on the dog side, but research has demonstrated the following:
 - Improved outcomes following cruciate surgery
 - Improved neurologic function following spinal cord insult
 - Improved comfort for chronic lameness conditions

Commonly used goals/techniques/modalities:

- Accelerate healing via increasing vascular perfusion, stimulating growth factor release, increasing the local stem cell population, accelerating metabolism, etc.
- Neuroplasticity to improve muscle mass, weight bearing, strength, co-ordination, neurologic function, flexibility, counteract reflex inhibition, etc.
- Pain control to improve quality of life, facilitate a return to normal function, and reduce the chance of secondary maladaptive pain syndromes

Background Concepts

Tendinopathy vs Tendinitis

- Acute injury causes tendinitis, but the inflammation quickly abates
- Repeated insults during the healing process can disrupt healing, leading to non-progressive or slowly degenerative changes: aka tendinopathy
- Tendinopathy is the most prevalent form of chronic tendon issue, and the lack of inflammation is a reason why it is frequently poorly responsive to NSAIDs (and NSAIDs may even impair healing)
- Treatment involves re-initiating the healing process and pairing it with appropriate exercise

Myofascial Trigger Points (mfTPs)

- A mfTP is hyperirritable focus of muscle within a taut band
- mfTP's are divided into active (hurt all the time) or latent (only hurt when palpated or muscle is engaged)
 - active points have a lower pH, and this may be why they hurt more
- routinely diagnosed by palpation, but can also be distinguished by EMG findings (mfTPs are a contracture with no EMG or motor end plate activity, vs muscle contraction/spasm which has EMG activity)
- mfTPs have a motor component (muscle weakness, stiffness and ROM), sensory component (tenderness, referred pain, peripheral and central sensitization – allodynia and hyperalgesia), and an autonomic component (stress is a cause in humans)
- are associated with migraines and myofascial pain syndrome in people
- Local twitch response (LTR) occurs with treatment and is proportional to the clinical response
- Proposed mfTP Etiology
 - Low level contractions (partial muscle fiber recruitment with low level static exercise – typing)
 - Uneven intramuscular pressure distribution affecting blood flow and causing hypoxia near insertion points
 - Direct trauma
 - Unaccustomed eccentric contractions (eccentric contractions cause an irregular and uneven lengthening of muscle fibers resulting in myalgia and weakness)
 - Maximal concentric contractions
 - Nutritional factors (vitamin B & D, and Fe deficiency)
 - Psychologic stress

Joint Physiology and Osteoarthritis

- Cartilage is hydrophilic – water is drawn into proteoglycan matrix that is linked by a web of collagen
- Collagen loss is permanent but proteoglycans turnover every 300 days
- Compression of cartilage “squeezes” out the water to provide shock absorption
- Short duration weight bearing circulates nutrients from synovial membrane into cartilage (walking/movement is good for the joints)
- As arthritis progresses, cartilage thins and chondrocytes die
- Thinning cartilage leads to hardening of the subchondral bone (sclerosis) which changes mechanics and leads to further thinning of the cartilage
- A tipping point exists beyond which normal cartilage physiology cannot be restored and progression of the arthritis is inevitable

Nitrous Oxide

- 2 constitutive forms (endothelial and neuronal) that have a protective function
- Inducible form secondary to trauma is a major contributor to acute vasodilation
- In addition to its primary effects on vascular tone and platelet function, it plays roles in inflammation and pain perception that has relevance in osteoarthritis
- Has both pro and anti-inflammatory properties – goldilocks zone

The body is a stingy dumpster diver

- Although we think of the body as an electrochemical machine deriving its fuel from the molecular potential of food, it is quite happy to accept other energy forms
- For example:
 - Cartilage compression gives rise to cartilage matrix synthesis by chondrocytes via ion streaming potentials created within cartilage when electrolyte rich fluid flows past. This affects joint health by increasing GAG levels, upregulating TGF beta gene expression, and other possible anti-inflammatory actions
 - Piezoelectricity generated during bone deformation due to electrolyte fluid moving through bone channels to trigger bone remodeling and repair
- The body seems to metabolically incorporate other forms of energy as well... including electricity, shockwaves, photons, sound waves, and electromagnetic fields

Modalities

Acupuncture (AP) and Electroacupuncture (EAP)

- Needles can be applied to acupoints which are associated with neural pathways and distinct neuroanatomic features (TCM style), or can be inserted directly into mfTPs (IMS style)
- The effects of EAP generally are more profound and last longer compared to those of AP.
- Indications
 - Muscular pain (mfTP, hypertonia), neurologic stimulation (neuro deficits/injury)
- Mechanism
 - Local effects: mediated by the release of various chemicals resulting in increased blood flow to counteract the hypoxic state within mfTPs
 - Systemic effects: stimulates the periaqueductal gray area and raphe nucleus to release inhibitory serotonin, NE and monoamines that stimulate the substantia gelatinosa to release endorphins, enkephalins and dynorphins into the CSF
 - EAP incorporating low frequency/high intensity current has opioid mediated effects, and high frequency/low intensity current is GABA mediated.
 - High frequency has more profound but shorter duration of effect
- Research
 - Multiple studies have shown beneficial effect of AP in dogs with IVDD – both in reduction of pain and improving recovery
 - 90-100% of grade I/II IVDD (pain +/- paresis but ambulatory) respond to AP based on several studies
 - EAP indicated for gd III/VI (non-ambulatory +/- sensory deficits)– one study showing 85% improvement over 2-6 weeks
 - Mechanism might reflect inflammatory modulation in spinal cord
 - Inflammation appears to be more important than compression in the development of neuro Cx; human CT study found no correlation b/w degree of compression and neuro Cx

Manual Therapy

- An umbrella term for chiropractic style manipulations, physiotherapy style mobilizations, stretching and massage – any “hands on” physical technique of tissue manipulation
- Manipulations consist of a single low amplitude, high velocity thrust (aka “adjustment”)

- Mobilizations are sustained or oscillatory movements divided into 4 grades (grades I/II for pain reduction, grades III/IV for increasing ROM)
- Neither technique has consistently proven to be superior over the other

Manipulations & Mobilizations

- Indications
 - Improve tissue extensibility and ROM, induce relaxation, reduce pain/swelling/inflammation
- Mechanism (Manipulations)
 - Centrally mediated effect on the nervous system
 - Likely reflects stimulation of the Golgi tendon or inverse myotatic spinal reflex to facilitate muscle relaxation
- Mechanism (Mobilizations)
 - Stimulates large diameter mechanoreceptors to ease pain and improve willingness of patient to move
 - Likely works through periaqueductal gray area and descending spinal cord inhibition but likely not opioid – more likely norepinephrine than serotonergic
- Research
 - Human meta analytic research has shown benefit to manual therapy over placebo, but conclusions vary as to whether it is superior to NSAIDs
 - No RCT research yet in dogs using manual therapy as the sole modality

Stretching

- Indications
 - Been shown to improve muscle force production, velocity of contractions and maximal volitional contraction – more research required to see if it improves athletic performance
 - Increases ROM and flexibility
 - Does not confer protection from muscle soreness or sports injury
- Mechanism
 - Immediately elongates elastic component of musculotendinous unit
 - Chronic stretching results in added sarcomeres to lengthen muscle
- Research
 - Labs with stifle or elbow OA had owners do 10x10sec stretches BID for 21d to increase ROM 14 degrees

Massage

- Indications
 - Primary benefits are pain relief, reduced spasm, and increased tissue extensibility (flexibility)

- Intent to increase blood flow, increase lymph drainage, and stretch connective tissue
- Mechanism
 - Deep painful massage may offer extended relief via descending analgesic pathways, short term via gate control theory of pain
 - Swelling can give rise to pain, decreased ROM and reflex inhibition of the surrounding tissues leading to atrophy and weakness
 - Massage causes a 22-fold increase in lymph flow
 - If improve muscle function, will automatically improve lymph drainage
 - Believed to replenish fluid in different compartments, bringing in more nutrients, removing substance P, prostaglandins, waste products etc. to reduce chronic pain
 - No evidence that massage reduces post exercise metabolites, or affects muscle blood flow
- Research
 - Human research indicates benefits of massage for pain control, but is limited by poor methodology (hard to blind people as to whether or not they received a massage, or were part of the control group)
 - To the best of my knowledge, there is no dog specific clinical research on the effectiveness of massage (and I've looked)

Combined Acupuncture and Manual Therapy (CAMT)

- Blinded randomized controlled therapeutic trial found that 2 CAMT treatments provide immediate short-term improvement in comfort and mobility, as demonstrated by owner observed changes in:
 - play behavior ($P = 0.015$)
 - walking ($P < 0.001$)
 - trotting ($P = 0.002$)
 - jumping ($P < 0.001$)
 - descending stairs ($P = 0.003$)
 - rising from a lying position ($P < 0.001$)
 - reduced stiffness after rest ($P < 0.001$)
 - reduced stiffness exercise ($P < 0.001$)
- Mood, attitude, and stair ascension also improved, but did not attain statistical significance
- No contra-indications for CAMT were found
- Many of the above variables showed significant improvement after just 1 treatment

Transcutaneous Electrical Neural Stimulation (TENS)

- Indications
 - Accelerate healing
 - Reduce edema and muscle spasm
- Mechanism

- Wound healing via enhanced galvanotaxis, cell stimulation, enhanced blood flow, reduced edema, and enhanced autolysis
- Pain control via gate control of pain
 - Works best for localized pain of moderate intensity in superficial locations
- Mechanism of affect depends on the frequency of the electricity (see EAP above)
- Motor TENS (aka acupuncture like TENS) 1-10Hz 100-400us pulse duration
 - Thought to release opiates via descending pathways for longer duration 1-3h after a 30 minute treatment
 - Has more delayed onset pain relief
- Sensory TENS (aka high rate/freq TENS) 40-150Hz 50-100us pulse width
 - Targets A-beta nerves and gate control for pain
 - Releases enkephalins in dorsal horn and stimulates delta opioid receptors, as well as GABA to reduce central sensitization
- Amplitude remains sub motor
- Research
 - Human research demonstrates effectiveness for chronic MSK pain relief
 - Mixed research findings whether high or low frequency, or combined high and low frequency works best
 - Canine study showed increased GRF 30min after Tx, effects lasted for 210min
 - Only mild improvement 4d afterward, not statistically significant
 - Combined with weight loss in DJD dogs, TENS dogs lost more weight and were less lame 6 months out
 - Conclusion that dietary management and rehab that includes TENS improved overweight dogs vs diet alone

Neuromuscular Electrical Stimulation (NMES aka E-stim)

- Indications
 - To prevent disuse atrophy following neural injury and/or surgery
 - Doesn't build strength better than voluntary ROM, and less effective than resistance work
 - May be more effective than volitional exercise for preventing atrophy and overcoming reflex inhibition for 1st few days to weeks post-op
 - Not helpful on normal subjects
 - Facilitate training for activities of daily living in neuro patients
 - TENS and NMES wave forms essentially the same – different effects are with pulse duration or width, and pulsing frequency
 - Is basically TENS directed at Alpha motor nerve
- Mechanism

- Electrical is all or nothing recruitment (vs selective recruitment of voluntary recruitment)
- Prevents type II fiber atrophy more than type 1
- Increases perfusion of muscles
- Research
 - Post cruciate surgery: 1st 14d post-op NMES plus ROM improved muscle mass, but controls eventually caught up, better extension with NMES, flexion the same as with controls
 - Research on cruciate deficient stifles utilizing co-contraction of hams/quads 4d/wk 30min for 4wks decreased bony change, improved thigh circumference and subjective lameness scores, resulted in better cart thickness, fewer osteophytes, but ROM, laxity, and kinetic values same as controls... but NMES dogs had greater meniscal damage

Laser

- Indications
 - Reduce inflammation, decrease pain, and promote tissue healing
 - Increase perfusion of mfTPs
- Mechanism
 - Little effect on non-injured cells
 - Metabolic effects:
 - Photons absorbed by cytochrome c oxidase in mitochondria to stimulate the respiratory chain for ATP production and modulation of cell signaling
 - Production of NO increases blood flow, and changes in inflammatory signaling
 - Changes to cell membrane permeability
 - Promote fibroblast development and synthesis of collagen
 - Hastens bone healing
 - Growth factor release
 - Decrease PMN influx
 - Increased angiogenesis to enhance revascularization
 - Increase leukocyte phagocytosis; stimulates the immune system
 - Stimulates stem cells
 - Reduced COX and PGE2 production
 - Pain Control:
 - Mediated by reducing inflammation
 - May effect nerve conduction velocity and evoked potentials
- Research
 - OA:
 - Laser of OA reduced edema 23%, vascular permeability 24%, pain 59%
 - Humans saw reduced pain but no change in ROM

- Meta-analysis on OA in people with laser – some showed no pain decrease, some showed big improvement
- Anti-inflammatory effects have been shown by reduction in specific inflammatory markers (prostaglandin E₂, interleukin 1 β , tumour necrosis factor α), in in-vitro and in-vivo animal studies and in man.
- In animal studies, the anti-inflammatory effects are similar to those of pharmacological agents such as celecoxib, meloxicam, diclofenac, and dexamethasone.
- Tendon:
 - Most effective for acute tendonitis vs tendinopathy
 - Improved collagen organization with partial tears – early Tx for 5d had optimal effect
 - Meta-analyses – half show positive effect and half inconclusive or no effect
- Nerve Damage
 - Rat crushed nerve research usually shows that laser promoted recovery, especially early post trauma
 - Laser helped recovery of chronic brachial plexus avulsions in people
 - Increases functional activity, decreases scar tissue formation, decreases motor neuron degeneration, increases axonal growth and myelination on spinal cord – high dosages 21d straight
 - Enhances axonal sprouting, astrocyte proliferation and myelin production, as well as protein and growth factors production
 - Accelerated response of spinal dogs vs no laser – decreases time to ambulation

Therapeutic Ultrasound

- Indications
 - Facilitate healing by increasing blood flow, collagen extensibility, and metabolic rate
 - Decrease pain by reducing muscle guarding/spasm, and increasing pain threshold
 - Increase flexibility by combining deep heating with aggressive stretching to break down fibrous or connective tissue
- Mechanism
 - Thermal effects:
 - Can provide deep (5cm) heating to increase extensibility of connective tissue
 - Decrease muscle spasm
 - Non-Thermal (mechanical) effects:
 - Mediated via microstreaming and stable cavitation
 - Reduce C fiber nerve conduction

- Facilitate fluid movement, stimulate angiogenesis, and increase cell membrane permeability
 - Basically facilitates normal healing
 - Mostly beneficial as adjunct to stretching
- Research:
 - 15min Tx 5x/wk for 2wk then 2x/2k for 5wk for carpal tunnel had less pain 6 months later
 - Human meta-analysis demonstrated 13% improved knee OA pain reduction, and increased functional movement

Extracorporeal Shockwave Therapy (ESWT)

- Indications:
 - Stimulate repair of delayed or non-union fractures (as well as stabilizing loose press-fit THR)
 - Palliative for OA pain
 - Pain control more consistent in chronic patients than acute
 - Increased tendon and ligament repair
 - Soft tissue ossifications
- Mechanism
 - Short term inhibition of C-fiber afferent pain signals, and impaired synthesis of substance P
 - Significant osteogenic response, specifically callous formation and bony remodeling
 - Destruction of calcifications
 - Exact mechanism undetermined but suspected increase in cytokines and growth factors, NO, bone morphogenic protein
 - May release inflammatory mediators, facilitating progression of healing
 - Causes drop in IL and TNF in OA joints
 - MSC recruitment
 - Increased serotonin activity in dorsal horn and descending inhibition of pain
 - Not seem to be opioid mediated
 - Stimulates neovascularization
 - May also increase cell membrane permeability
- Research
 - Coxofemoral OA dogs showed increased GRF 4wk after Tx that may last 3m
 - Stifle OA 3 sessions weekly apart showed increased GRF at 21d that persisted at 98d
 - Non-unions respond with the same success rate as repeat Sx (up to 100%)

- Treatment of biceps or supraspinatus tendinopathy demonstrated 85% of dogs had good or excellent outcomes determined by owner assessment 11–220 weeks after therapy.

Pulsed Electromagnetic Field Therapy (PEMF)

- Indications:
 - Facilitating healing of wounds, tendons, and bone
 - May attenuate bone loss due to disuse - used with delayed/non-union fractures, but may delay healing of acute fractures
 - Palliative treatment of OA
- Mechanism:
 - PEMF thought to have more electric than magnetic effect – acts on cell surface receptors such as PTH and TGF-beta, and secondary messengers such as calcium and cAMP
 - Increases NO production
 - Polarizes hydrogen and oxygen in water, and iron becomes polarized to align with other components in blood, allowing charged molecules to travel more efficiently through cell walls to increase nutrition flow
 - May reduce free radical production
- Research:
 - 21d daily Tx accelerated wound closure
 - Conflicting or weak evidence re: accelerating bone healing but appears to be helpful for delayed and non-union fractures
 - Cochrane review found 13-23% benefit for OA – increased ROM, decreased pain
 - Retards OA development in guinea pigs
 - Benefits are of short duration for OA
 - RCT clinical trial in 60 dogs found helped early Z-peak, CBPI scores, joint extension, and thigh circumference for OA patients
 - Increases cartilage matrix synth in vitro and in vivo

Therapeutic exercise

- Indications:
 - Injury prevention
 - Facilitating return to full function after trauma, surgery etc.
 - Improve strength, speed, co-ordination, endurance, stability, athletic performance
- Mechanism:
 - Way too much information to try to summarize... let's just go with recognizing that exercise is good for the body
- Research

- Human meta-analysis determined that strength training is the single best method to prevent sports injury, reducing acute injury by 1/3 and repetitive stress injury by 1/2
- Unpublished data from the Penn Vet Working Dog research facility demonstrated that the addition of a conditioning program increased the average retirement age from 8 to 11 years
- Fitness programs affect cardiovascular health by lowering resting HR, increase VO₂max by 30-40%, increasing cardiac output 30-35%, and reducing vascular resistance 25%
- Fitness programs improve muscles by increasing muscle fiber area, utilization of elastic energy, strength, resting glycogen levels, oxidative capacity, motor unit activation, neural drive, tendon cross sectional area, and bone density

Orthotics/Prosthetics

- Orthotics are to support, align, prevent deformity, assist weak muscles, and/or improve function
 - Serve a longer-term function than splints do
- Prosthetics are used to augment function in shortened limbs

Regenerative Medicine

- Mesenchymal Stem Cells (MSC) – a pure culture of cells without additional growth factors etc.
- Stromal Vascular Fraction (SVF) – a collection of many growth agents, including MSC's
 - Frequently derived from either adipose, or bone marrow
 - ADSCs – Adipose Derived Stem Cells
 - BMAC – Bone Marrow Aspirate Concentrate
- Platelet Rich Plasma (PRP) – a 3-5 fold concentration of autologous platelets in a plasma suspension
- ACS - Autologous conditioned serum which contains high concentration of growth factors and anti-inflammatory cytokines
- Indications
 - Tendon/ligament repair (MSC or SVF, plus PRP)
 - Palliative treatment of OA (PRP, with or without MSC or SVF)
 - Maladaptive pain (combined MSC or SVF, plus PRP)
 - IVDD and CNS conditions
- Mechanism (PRP)
 - PRP works primarily through the release of multiple growth factors (PDGF, IGF I & II, TGF-B1, VEGF, FGF, EGF, osteocalcin, osteonectin, fibronectin, thrombospondin-1)

- Triggers genes responsible for cell proliferation, tissue/osteod production and collagen synthesis
- May continue to release growth factors for several days
- There is a synergy between MSC/SVF and PRP – certain growth factors and cytokines from platelets bind to stem cells and initiate signal transduction, gene expression, and MSC proliferation
- PRP also provides a scaffold to support cell survival and proliferation
- Mechanism (MSC/SVF)
 - Anti-inflammatory
 - Anti-apoptosis
 - Neurotropic factor production
 - Stimulates mitosis of neuroprogenitors
 - Antifibrosis
 - Angiogenesis
 - Recruits circulating stem cells*
 - Delivers a population of cells able to communicate with other cells in local environment
 - Immune modulation and secretion of cell signaling factors and cytokines for local and remote effects
 - Central and peripheral effect in modulating neuropathic pain
 - Opioid production and opioid receptor agonist
 - Profound effect on mechanical allodynia and thermal hyperalgesia suspected via reduction in LI-1beta and IF-17 and increase in IL-10
- Research
 - Supraspinatus tendinopathy treated with ADSC combined with PRP – 88% showed complete resolution, and the remaining 12% showed partial improvement
 - PRP has shown more consistent benefit as and IA injection for OA than MSCs – not enough research on combined MSC/PRP
 - Different PRP systems yield different products which makes comparison difficult
 - Many more in-vitro papers than actual clinical trials. Unknown if cultured better than fresh SVF, or if ADSC better than BMAC, or vice versa.
 - Multiple papers do suggest that combining MSC or SVF with PRP is synergistic

A Sports Medicine Approach to Select Conditions

OA

- Arthritis treatment options include the following:
 - Treatment applied to all dogs:
 - Weight control
 - Exercise modification
 - Nutraceuticals
 - Address any secondary or concurrent sources of pain
 - Improve fitness
 - Targeted treatment of affected joints:
 - ESWT
 - PRP +/- MSC
 - Laser
 - PEMF
 - Pharmaceuticals
 - Orthotic support
 - Salvage surgery (FHO, THR, TKR, CUE, arthrodesis, etc.)

Flexor Enthesopathy of the Elbow

- Concomitant or primary flexor tendinopathy was previously known as ununited medial epicondyle, dystrophic calcification of the flexor tendon origins, traumatic avulsion of the humeral medial epicondyle, medial humeral condylar osteochondritis dissecans, and/or development of a preformed ossification center
- Researchers found an incidence of 6% for primary flexor enthesopathy and 34% for concomitant flexor enthesopathy, indicating that primary flexor enthesopathy is as frequent as OCD and more frequent than UAP
- Radiographic changes in the epicondylar region can be minimal, inconclusive or even absent, so additional imaging techniques are necessary (ultrasound, MRI, arthroscopy). Primary enthesopathy often has subtler radiographic signs than concomitant does. Spur formation most common sign
- Radiography can be considered as a first screening method for the detection of flexor enthesopathy, but a relatively large number may be missed. A 15 degree oblique Crlat-Cdmed view highlights it best (just like OCD)
- Look for evidence of carpal flexor pain and treat like other tendinopathies (rehab, laser, ESWT, MSC/PRP) as either primary therapy, or to augment OA or surgical treatment

Hip dysplasia

- Most HD cases do not require surgery:

- 38 of 50 immature dogs with hip dysplasia had a long-term outcome (mean follow-up 3.8 years) of either a normal gait or only slight or intermittent abnormalities.
- A retrospective examination of the long-term effects of hip dysplasia on military working dogs found no significant difference between the total number of months worked by normal and dysplastic dogs
- The radiographic finding of hip dysplasia has not been associated with the early retirement of guide dogs
- HD dogs show no direct correlation between the degree of pain and the severity of radiographic changes within the joints!!!
- Not all hip region pain necessarily comes from the coxofemoral joints
 - Rule out concurrent or primary lower back pain, SI joint issues, LS pain, iliopsoas pain, hip flexor muscle pain, etc.

Biceps tendinopathy

- Transection of the biceps tendon should be considered a salvage procedure, only to be attempted after other modalities have failed, or if >75% of the tendon is torn
- The biceps tendon crosses the shoulder joint and provides a stabilizing function. That function is lost when the tendon is transected. We do not know how much this change in stability predisposes the remaining shoulder stabilizers (e.g.: supraspinatus) to further injury
- Although RCT research is lacking on other treatment options (hence the propensity to transect the tendon), the work on either ESWT or MSC/PRP for supraspinatus tendinopathy, combined with anecdotal experience, merits consideration
- IMHO - Mild cases may respond to therapeutic exercise and laser, with shockwave employed for moderate cases with no large defects. MSC/PRP is the treatment of choice for larger defects or dogs that will return to harder activity

Cruciate disease

- Unstable joints do best with surgery, especially those with meniscal tearing
- Stable joints may or may not respond to therapeutic exercise, combined with laser, orthotic brace, +/- ESWT
- Orthotic braces can be used to:
 - augment the treatment of stable joints (above)
 - ongoing protection of stifles that responded to conservative Tx
 - improve comfort of unstable knees with no meniscal tearing in non-athletic dogs
 - augment surgical repairs of complicated surgical cases (e.g.: deranged stifles)
 - Research found that knee braces improve weight bearing in CrCL deficient dogs, but not as much as surgery does

- Owner surveys found >85% of clients that chose orthotics instead of knee surgery were satisfied with their choice
- MSC/PRP
 - 36 dogs with <50% tearing of the craniomedial band
 - 7 progressed to surgery within 2 years (just under 20%), vs expected 85% in 3 years
 - 13 underwent repeat arthroscopy – 3 had not responded (part of the 7 surgeries mentioned above), 1 partially responded and received a repeat treatment, and 9 “had marked neovascularization and a normal fiber pattern with all previous regions of disruption healed”
 - 12 questionnaires were returned, of which 8 were performance or sporting dogs. 7/8 had returned to sport; the remaining dog had just begun a return to sport conditioning program 6 months post treatment. 5/8 had returned to the same level of performance, and 2/8 were performing at a higher level than they had pre-treatment
 - All 12 respondents believed that their dog had an excellent or very good quality of life and rated their dog’s procedural outcome as excellent or good.
 - The degree of tearing was not found to be a prognostic indicator
 - Some of the treated dogs had mild laxity
 - Use of an orthotic did not correlate with outcomes
 - IMHO – better patient selection is required. Consider as an option for dogs with a known history of trauma, unilateral disease, and no tissue laxity.

Back Pain and Spinal Cord Dysfunction

- Non-surgical spinal cord dysfunction lends itself to sports medicine modalities. Consider the following when deciding where to refer a patient:

Refer to an ACVN	Refer to an ACVSMR
<ul style="list-style-type: none"> ● Non-ambulatory patients with an open diagnosis ● Patients experiencing acute a/o rapidly degenerating spinal cord function ● Patients with severe, and/or continuous pain, especially if it is refractory to parenteral pain control 	<ul style="list-style-type: none"> ● Ataxic or paretic patients seeking non-surgical palliative care ● Patients who have declined a neurologist consult, including non-ambulatory patients ● Ambulatory patients with intermittent, or mild to moderate back pain ● End goal is to achieve spinal walking

Prognosis of success graded by degree of dysfunction at presentation. *Conservative Tx and Surgery statistics taken from Lorenz & Coates 5th ed. Numbers with an “*” indicate that they are based on a single study only. Please don’t take these numbers as absolutes...*

Description	Conservative Tx (cage rest)	Tx including AP or EAP	Surgery
Paraplegia with no deep pain sensation >48h since onset	<5%	79%*	6-33%
Paraplegia with no deep pain sensation <48h since onset	>5%	58%*	45-76%
Paraplegial with deep pain but no superficial pain perception	50%	58%*	86-89%
Paraplegia with intact pain perception	51%	85%*	79-96%
Non-ambulatory paraparesis	55-85%	85%*	83-95%
Ambulatory paraparesis	55-85%	90-100%	83-95%
Spinal hyperesthesia only	55-85%	90-100%	83-95%

- Sports medicine treatment options include AP/EAP, laser, ESWT, CAMT, therapeutic exercise

USMI

- IMHO - Lower back pain is correlated to USMI in dogs, and should be considered to be one of the causes in this multifactorial disease.
- CAMT, with or without laser therapy has proven successful in partially or completely resolving USMI in a substantial proportion of dogs.