sports.medicine. newspaper

2023
international edition of
sportärztezeitung

WWW.SPORTAERZTEZEITUNG.COM

REGENERATIVE THERAPIES

Cornelius Müller-Rensmann MD

OVERVIEW OF THE POST FIFA WORLD CUP 2022 PLAYERS WORKLOAD REPORT

Amr Farag MD

MINCED CARTILAGE IMPLANTATION

Jakob Hax MD,
Prof. Gian Salzmann MD,
Assoc. Prof. Armin Runer MD

RETURN TO PLAY AFTER INFECTIONS

Alexander R. Tamm MD,
Simon Diestelmeier MD

THE BURDEN OF HAMSTRING INJURIES IN PROFESSIONAL FOOTBALLERS

MR Sebastian Kunz

PHYTOPHARMACEUTICALS AND EXTRACORPOREAL SHOCK WAVE THERAPY FOR TENDINOPATHY

Anna-Lena Müller, Aranka Brockmüller, Dr. Christoph Schmitz M.D., Dr. Mehdi Shakibaei

ALTER G

DEFY GRAVITY. DEFY LIMITS.

WALKING ON THE MOON. FOR EVERYONE.

WITH PRECISE BODYWEIGHT SUPPORT

Orthopedic, Neurological & Long COVID patients
Seniors | Obesity | Athletes

Physiological gait pattern
when walking and running

Early, pain-free walking and running
after injury/surgery

Reduced metabolic requirements
for deconditioned patients

Safe endurance training
during rehabilitation for athletes

Clinical Resources

Scan the QR code and benefit from the advanced experiences of our users.

info@alterg.com | www.alterg.com
+1 (510) 270 5900

GREETINGS FROM THE PUBLISHER

Exchange of knowledge and exchange between experts – that is our mission. So we are proud to cooperate with the Isokinetic Conference 2023 in London and wish you an interesting conference with many innovative topics. Also, enjoy this issue. We look forward to seeing you again at the Isokinetic Conference in Madrid in 2024.

Best regards yours thesportgroup-Team

IMPRINT

EDITOR
thesportgroup GmbH
J.-Pierre-Jungels-Str. 6 | 55126 Mainz

Tel.: +49 6131/240 53 17
info@thesportgroup.de
www.thesportgroup.de

DIRECTORS
Robert Erbeldinger | Joachim Messner
Trade registry: Mainz HRB 46334
International VAT-ID: DE 301342633

EDITORIAL STAFF
Masiar Sabok Sir | editor in chief
sabok@thesportgroup.de

Robert Erbeldinger
Patrick Göller
PD Dr Felix Post MD

ADVERTISEMENT
Robert Erbeldinger

Patrick Göller + Events
goeller@thesportgroup.de

In accordance with the prices listed in June 2021

DESIGN, LAYOUT, PRODUCTION
Angelique Sarka | Art Director
sarka@thesportgroup.de

PRINT
Printed on 100 per cent recycling paper (Certificates: Blauer Engel, EU Eco-Label, Nordic Swan) by AC medienhaus GmbH, Wiesbaden-Nordenstadt

FURTHER INFO
ISSN: 2365-8754 | Volume 8 | International Issue 2023

COVER
© imago IMAGES / Sportpix

REGENERATIVE THERAPIES

Regenerative medicine in outpatient medical care

CORNELIUS MÜLLER-RENSMANN, MD / ORTHOPAEDIC PRACTICE MÜNSTER

Orthobiological methods have been used in professional sports for years and the trend is growing. Muscular, tendinous and even degenerative disorders are already being treated in many different types of sports with platelet rich plasma (PRP), the blood cell secretome (BCS), and, in rare cases, with cells aspirated from bone marrow biopsies or stem cells derived from endogenous adipose tissue.

The industry supplies various products and systems as can be seen in Table 1.

Some of the products such as PRP or BCS/Orthokine are simple to produce and practical to administer in a sports medicine specialist's everyday practice. They both act by virtue of their contents, particularly the interleukin 1 receptor antagonists, but also diverse so-called growth factors during the proliferative phase of healing after injuries (Fig. 1). Unfortunately, very different products with regard to their contents are subsumed under the term PRP. This makes it difficult to conduct generally valid level 1 studies. Thus no recommendations have yet been made for PRP due to the stringent criteria of the guidelines committee. However, it has been acknowledged that there are already powerful study results that clearly point to a significant effect that is possibly better than that achieved with hyaluronic acid.

These regenerative methods are no longer a rarity in statutory health and private healthcare in Germany either. And this is most likely also justifiable. In the meantime, the data on file for PRP are very good, at least for its use in osteoarthritis of the knee, but also for, e.g., epicondylitis. In fact, it is so good for osteoarthritis of the knee that the European Society of Sports Traumatology, Knee Surgery & Arthroscopy (ESSKA) has recommended using PRP for osteoarthritis as, for instance, Mandelbaum (FIFA Excellence Center St. Monica USA) reported at this year's Isokinetic Conference in Lyon (Fig. 2), (see also the article by Prof. Tischer on page 28 of this issue).

More recent studies have also been published for hyaluronic acid that have proved its efficacy particularly in osteoarthritis of the knee, but also for certain disorders of tendinous tissue such as Achilles tendinopathy in combination with radial shockwave therapy or for disorders of the rotator cuff (M. Khan Sports Health 2/22). However, hyaluronic acid is not an active regenerative substance in the strictest sense. Nevertheless, it does exert a protective effect by reducing prostaglandin E2 and metalloproteinases that have negative effects on the integrity of the articular cartilage matrix. Hyaluronic acid can also be interesting, especially in combination with actively regenerative blood products. The combination of the two different modes of action could help in the fight against osteoarthritis of the knee. Due to the very good study data now on file regarding its efficacy, hyaluronic acid has been included for the first time in the new guidelines for osteoarthritis of the knee. It is recommended for those cases when other therapeutic measures such as dietary counselling and physical exercises do not have an adequate effect.

DOCTOR'S OBLIGATIONS & MULTIMODAL THERAPY CONCEPT

However, the emancipation of these therapeutic measures in the field of

TAB. 1 Blood and cell products *J. Olmo 2022*

AUTOLOGOUS BLOOD PRODUCTS		
PRP	Leukocyte Poor-PRP (LP-PRP)	ACP, Arthrex, A-PRP, Regenlab, Cascade, MTF, Clear PRP, Hervest
	Leucocyte Rich-PRP (LR-PRP)	GPSIII, ZimmerBiomet, Angel, Arthrex, GenesisCS, EmCyte, Magellan, Arterlocyte, SmartPRcP, Harvest
Autologous Antinflammatories (AAIs)	Autologous Protein Solution (APS)	nStride, ZimmerBiomet
	Autologous conditioned serum	Orthokine, Orthogen
CELL-BASED THERAPIES		
'point of care cell based therapies'	Bone Marrow aspirate	BMAC, Harvest, Angel, Arthrex, Pure BMC, EmCyte
	Stromal Vascular Fraction (SVF)	Adiprep, Harvest, Progenkine, EmCyte, ACP SVF, Arthrex
	Micro-Fragmented Adipose Tissue	Lipogems
cultured`mesenchymal	Autologous MSCs	LifePlus Stem Cells
Stromal Cells` (MSCs)	Allogeneic MSCs	LifePlus Stem Cells

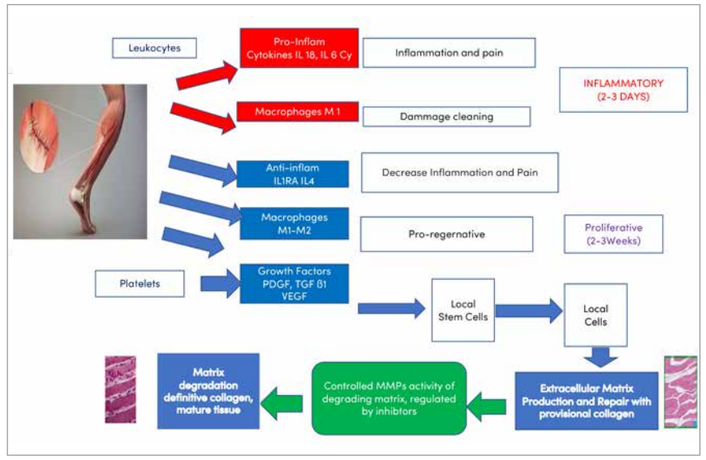


FIG. 1 MSK Acute Injury *modified Bert Mandelbaum*

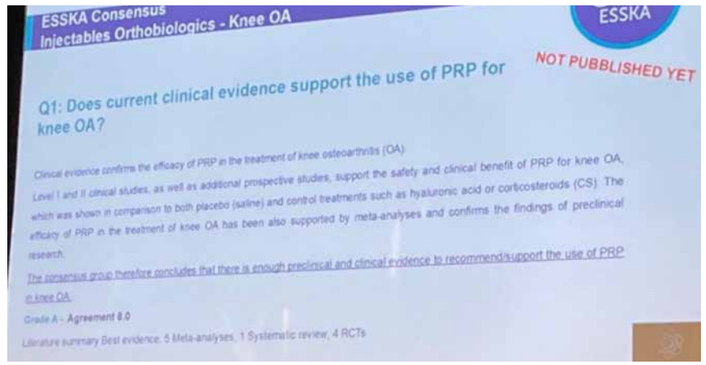


FIG. 2 *modified Bert Mandelbaum*

CORNELIUS MÜLLER-RENSMANN, MD

is a specialist for orthopaedics and owner of an orthopaedic practice in Münster specialising in sports orthopaedics. He is also club doctor at SC Preußen Münster and team doctor of the DFB U16 national team.

orthobiology imposes obligations on attending physicians in Germany. Paragraph 630e, German Civil Code (BGB) states: "..Alternatives to the measure must also be referred to in the briefing if several equally medically indicated, customary methods may lead to significantly different strains, risks or chances of recovery". This means that, in future, the doctor providing the information will be well advised to talk about Orthokine, PRP and hyaluronic acid at least when making a diagnosis of osteoarthritis of the knee joint. According to the opinion of experts and in compliance with the guidelines, the use of these orthobiological therapies is only sensible and successful when embedded in a multimodal therapy concept. In this case this especially means optimisation of the biomechanical parameters with medicinal products and medical devices as well as educative approaches such as, and in particular, nutritional counselling. Besides the development of special scaffolds, the further development of blood products rich in growth factors and the harvesting of pluripotent stem cells also play a major role in reconstructive surgical procedures for degenerative disorders. Brunella Grigolo (SSD Laboratory RAMSES, Rizzoli Orthopaedic Institute, Bologna) sees this development as an "important turning point in the clinical treatment of numerous disorders of the musculoskeletal system".

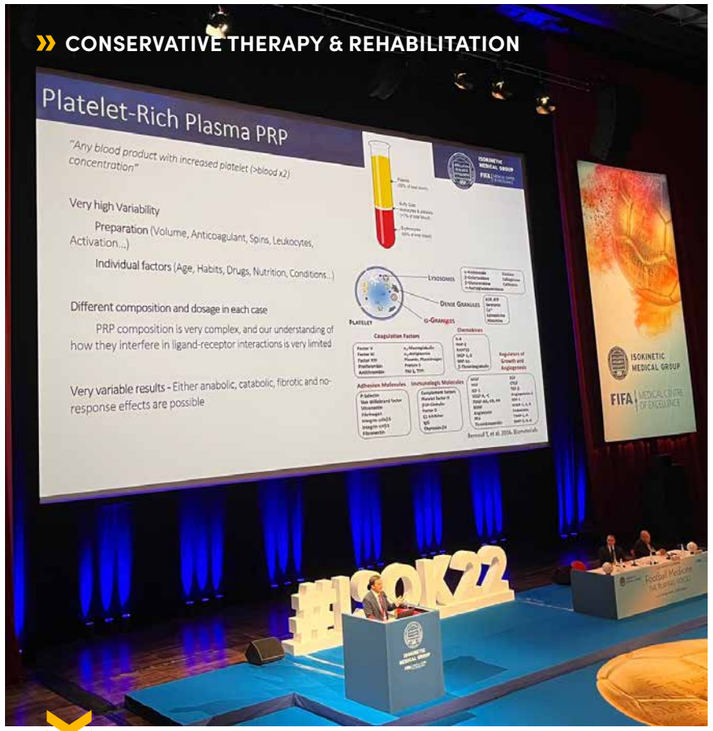
Against the background of the current study data and the assessment by the FDA, Bert Mandelbaum (Department of Orthopaedic Surgery Cedars, Sinai; FIFA medical center of excellence, Los Angeles) sees the various orthobiological regenerative methods within the context of a traffic light system (Fig. 3). He already recommends a few methods (green) for use in top athletes with acute injuries and for standard care in selected indications.

SUMMARY

Regenerative medicine has sparked great expectations. The orthobiologics developed to date can shorten recovery times, particularly in athletes, which brings considerable competitive advantages in professional sports. Moreover, it has also become established in standard surgical and conservative care by merit of a few products. Hyaluronic acid and PRP in particular must be considered when deciding on treatment for a number of indications. It is important to treat these new treatment options – whose mercantile aspects should be of secondary importance – seriously to avoid moving these methods unnecessarily into the critical focus of the funding agencies. The further development of "point of care" harvesting of stem cells and their combined use with growth factors promises to be exciting. Perhaps in the foreseeable future surgical and conservative methods will really be able to combine to heal tissue that to date has been considered unable to regenerate. Still just hope, but soon reality?

- **» Corticosteroids +/- Microspheres**
- **» Glucosamine/Chrondrotinsulfat**
- **» Hyaluronic Acid**
- **» PRP**
- **» Cytokine Modulation**
  - IL-Ira Inhibition of Inflammatory Response
- **» Stem Cell type procedures**
- Adipose derived
- BMAC
- Allogeneic stem cells
- Induced pluripotential cells
- **» Exosomes**
- **» Alpha- 2 Macroglobulin**
- **» Amniotic Fluid**
- **» Estrogens**
- **» M2 Macrophages (Entzündungshemmend)**
- **» Wnt (wingless INT 1) pathway inhibitors**

FIG. 3 Orthobiologics 2022 *modified Bert Mandelbaum 6/2022*



PRP DEFINITION JESÚS OLMO, MD "Any blood product with increased platelet (> blood x 2) concentration"

REGENERATIVE MEDICINE – A "HOT ISSUE"

Cornelius Müller-Rensmann MD and Robert Erbeldinger interview Jesús Olmo MD

Jesús Olmo MD spoke the words in the headline when opening his lecture during last year's Isokinetic-Conference in Lyon (www.isokineticconference.com/2022-edition/). In view of the ever-growing interest in this special field in biology and medicine he appears to be right.

In the future it could fulfil the dream of aiding the body's tissues to regenerate such that they actually regain their original condition after an injury. Even now, a number of blood derivatives, such as PRP or Orthokine, that this relatively young branch of medicine has developed support and accelerate healing after sports injuries. Dr. Jesús Olmo is CEO of the Football Science Institute in Granada, works in London for the Isokinetic Group, and was Director of the Medical Services of Real Madrid from 2013 to 2017. We took the opportunity to ask this friendly and expert colleague a few questions.

» Dear Jesús Olmo MD, could you please tell us in which cases you prefer PRP and in which cases you use orthokine?

It is important to know that there is not enough scientific evidence that one blood product outperform the others. According to my clinical experience, I prefer PRP for Knee OA management and Orthokine both for small joints (AC, hands, spine…) OA and for ligament injuries, where I find an important analgesic effect. Anyway, I use both as coadjutants of the first line treatment, which is biomechanics correction through specialized exercise.

» Do you have different experience between LR-PRP and LP-PRP? Which type of PRP is more efficient?

As said, it is not clear in the scientific literature if one is more efficient than the other. LR-PRP composition is richer in leukocytes and also platelets, inflammatory/catabolic factors such as the sCD40L and MMP-1, anabolic factors such as PDGF and TGF-β, and the anti-catabolic IL-1βRa, so potentially could have a more powerful effect and maybe a better role in improving acute injuries healing if applied on the first hours. But it also has more adverse effects (15 – 20 % in terms of swelling and pain), and even if LR-PRP has shown to work better in pathologies such as epicondylitis, recent evidence seems to deny any clinical difference, so I feel that we still need to find the right indications for both products.

» Do you use some combinations of regenerative effective methods for example PRP and Hyaluronan acid?

I personally use the alternating combination of PRP and Hyaluronan for the management of the knee OA, as they have different effects: PRP elicit a biologic response, while hyaluronan is more related with a mechanical effect of cartilage protection. I'm finding good symptoms control with this combination and a prolongation of the time until a knee replacement is needed, but always if combined with biomechanics correction through specialized exercise as said before.

» What are your experience with concentrated Bone marrow aspirate in comparison to vascular associated pluripotent stem cells from the adipose tissue?

I don't have personal clinical experience with neither BMAC nor adipose-derived stem cells, as I use cultured bone marrow-derived stem cells, but it is important to highlight that any cell product must not be applied outside the proper legal framework (approved clinical trials or compassionate use in most countries) and there is no significant clinical evidence currently for the justification of the extra cost, morbidity and legal complexity of point-of-care procedures such as the BMAC, MFAT and SVF over blood products. On the other hand, cultured/expanded stem cells seem to offer a significantly higher potential effect on clinical outcomes, tissue healing and reversing of degenerative processes, with some game-changing results, so I think that – within a proper legal framework – bone marrow-derived mesenchymal stem cells can be the best option in top-level athletes, because there is an important difficulty and morbidity for fat tissue harvesting in lean, fit athletes, and also because their high cost is relative to the transcendency of many of these cases.

» Biological repair of the musculoskeletal system is one of the main purposes in orthopedics and traumatology. Where do you see the future? Which type of regenerative methods will be the most important in the subject of sports-medicine?

Regenerative medicine ultimate goals in sportsmedicine are two: Accelerating / Enhancing Acute Injury Healing and Slowing down / Reversing Chronic Pathology. So far, blood products are not clear to achieve these objectives, but provide a very useful clinical relief at mid-term, most in mild/moderate degenerative process. I think that cultured stem cells have the potential to achieve this goals, but we need to find methods that are more simple and practical, affordable, and better defined in terms of dosage, indications and timing. And of course, as associated therapy for the first-line treatment: control of the mechanical etiology of the injuries through biomechanics reconditioning.

CORNELIUS MÜLLER-RENSMANN, MD

JESÚS OLMO, MD

REGENERATIVE TREATMENT METHODS

with synergistic effects in the treatment of activated osteoarthritis
(Case studies: osteoarthritis of the knee and the shoulder)

RAUL BORGMANN, MD /
PRIVATE PRACTICE FOR ORTHOPAEDICS AND OSTEOPATHY, FREIBURG

In our daily orthopaedic practice we are repeatedly faced with acute patients who have activated osteoarthritis. In the light of today's understanding of the side effects and late complications of corticosteroids, their formerly widespread use for activated osteoarthritis is precluded today, for this indication as well.

For this reason, modern regenerative therapy concepts are needed here that lead to quick and lasting relief of symptoms. This is why the combination of different procedures with synergistic effects has proved to be so effective in our daily practice over the past years. We use hyperbaric CO2 cryotherapy (Fig. 1), high-intensity laser therapy, extracorporeal magneto transduction therapy (EMTT), focused extracorporeal shock wave therapy (ESWT), and PRP/hyaluronic acid injections depending on the constellation of findings.

CASE 1

Acute activated osteoarthritis of the knee following osteonecrosis of the medial femoral condyle (Ahlback's disease)

History

The active 64-year-old [female] patient, whom we had last treated at our practice in the spring of 2020, was already known to us. The patient has pronounced varus osteoarthritis that she developed a few years ago associated with Ahlback's disease with considerable bone oedema at the time (Fig. 2). She reported that she had been symptom-free for almost two years since our last treatment, and that she could cope well with her everyday living including moderate sporting activities. Now she had once again been exposed to high physical demands while clearing the home of her aged mother, and this had reactivated her symptoms again. She had already had a follow-up MRI performed recently and asked us to quickly start a new course of treatment.

FIG. 1

Clinical findings (at the first consultation 07/2022)

At the first consultation in July 2022 the patient rated her pain as 7 on a VAS, the right knee joint was giving her considerable pain on pressure in the region of the medial joint space and femoral condyle, the soft tissues here showed oedematous swelling with moderate effusion on clinical examination.

Imaging

The recent MRI of the right knee joint (06/2022) shows considerably activated varus osteoarthritis, now with increased bone oedema compared with the previous images, effusion associated with irritation, and a small Baker's cyst.

Diagnosis

Right-sided varus osteoarthritis reactivated by overuse with a history of spontaneous osteonecrosis of the knee joint (Ahlback's disease).

Procedure and course

First we gave her the following treatment combination 1 – 2x weekly for 4 weeks: to reduce the acute irritative state of the soft and synovial tissues: hyperbaric CO2 cryotherapy (Cryolight Elmako) and high-intensity laser therapy (BTL Highpowerlaser), pulsed using the acute programme to avoid generating heat in the tissues.

To reduce the newly activated bone oedema: extracorporeal magneto transduction therapy (EMTT) Magnetolith setting 8, 4 Hz, 4000 impulses. After only the first session with this treatment regimen we achieved pain reduction from 7 to 5 on the VAS, and this decreased relatively quickly to a VAS of 2 – 3 in the further course. The patient also reported very rapid regression of the peak pain on loading, while a significant reduction of the nocturnal pain at rest (which we associated with the pain of the bone oedema) was only noted after the 4th treatment. This matches the observation that we make with many patients treated with EMTT in which we need 3 – 4 treatment sessions to gain a significant reduction in pain. This is also one of the reasons why we work with at least two treatment sessions a week if possible. Once the patient was mobile enough to go for short hikes and ride her e-bike after this 4-week treatment series, we gave her another four treatments with the Magnetolith and cryotherapy to secure the treatment outcome and integrated her into individual medical training therapy for further dosed increased endurance for 2 – 3 months.

CASE 2

Activated osteoarthritis of the shoulder and tendinosis of the rotator cuff

History

This [female] patient was a 72-year-old medical doctor who actively participates in equestrian and cycling sports. She said she thought she had injured her right rotator cuff after falling off a horse over 10 years before, and had had repeated episodes of symptoms in her shoulder ever since. Since the symptoms had not been so pronounced for surgery to be considered, she had not yet requested any imaging and had only had sporadic physiotherapy. However, the symptoms had been worsening over the last few months and by now she could no longer sleep through the night, she could no longer lie on her right side, and almost all movements were limited by pain.

Clinical findings (At the time of her first appointment)

At the clinical examination she reported her current pain to be 7 on a VAS. Her movements, both passive and active, were considerably restricted. Placing her hand behind her neck was about 10 cm less on the right compared with the left, placing her hand between her shoulder blades from below was barely possible on the right, and movements of the scapula were considerably limited. Examination of the surrounding musculature showed active trigger points, above all in the subscapularis, trapezius and infraspinatus muscles.

Imaging

Ultrasonography showed pronounced intra-articular effusion extending along the long head of the biceps tendon, the supraspinatus tendon showed degenerative changes and thinning, and there

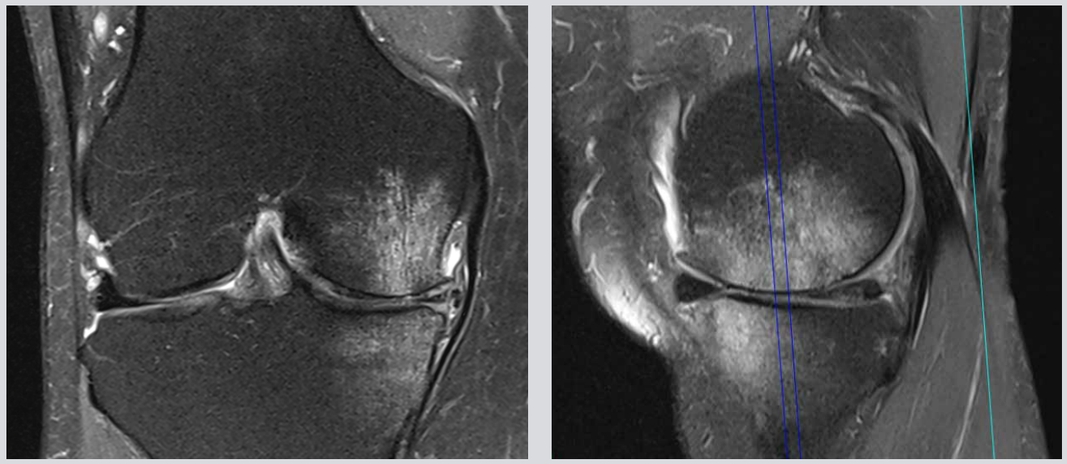


FIG. 2

RAUL BORGMANN, MD

is a specialist for orthopaedics and accident surgery, and has a diploma in osteopathy. He founded the private practice for orthopaedics and osteopathy in Freiburg and has been active in the field of regenerative medicine (ESWT, PRP, stem cell therapy, prolotherapy; Pain School International Budapest) for many years.

were also pronounced arthritic changes. The MRI requested after this showed advanced activated osteoarthritis of the shoulder, articular effusion, degenerative changes in the supraspinatus and subscapularis tendons compatible with tendinosis and fraying, but no transmural rupture.

Diagnosis

Activated osteoarthritis of the shoulder with articular effusion, rotator cuff tendinosis, restricted scapular movement and active trigger points (subscapularis and infraspinatus muscles).

Procedure and course

The following therapeutic procedures were started due to the first clinical and sonographic findings (only once weekly due to the 2-hour car journey here): low energy focused pericapsular shockwave therapy, treatment of the named trigger points by focused ESWT and dry needling, hyperbaric CO2 cryotherapy, EMTT Magnetolith 8/4/4000, kinesio taping and osteopathic treatment. This treatment regimen alone was able to reduce pain peaks substantially, and transient pain relief to VAS 2 – 3 was achieved directly after the treatments. During the 3rd and 6th treatment sessions the procedure was augmented with an i.a. injection of PRP and hyaluronic acid (CellularMatrix Regen Lab). The patient reacted to the first injection with considerable initial aggravation (VAS 6) for 2 – 3 days, followed by a slow, continuous improvement to a VAS of 2 – 3. After the 2nd PRP injection she again complained of initial worsening to VAS 3 – 4 for 3 days followed by further pronounced pain reduction to VAS 1 – 2. We continued the first-named treatments with cryo, ESWT and EMTT for some time at slightly longer intervals of 2 – 4 weeks and concluded treatment with a hyaluronic acid injection.

SUMMARY

While the evidence for the individual regenerative procedures described above has become pretty good over the last few years, apart from a few isolated studies there are as yet few scientific data on their combination, or any more precise understanding of how the individual signal pathways influence each other. However, as I understand the various modes of action, and on the basis of the holistic regenerative treatment approach practiced at our orthopaedic-osteopathic practice, the combination has always appeared logical and has been proven in daily practice. The combination is matched to the respective clinical picture and the predominating individual tissue structures for the pain symptoms. If the inflammatory irritation of the soft tissues and the synovia is more prominent we consider high-intensity laser (pulsed to generate as little heat as possible) to be most appropriate. If the bony stress reaction in the form of bone oedema predominates, EMTT is our treatment of choice. In our opinion, hyperbaric CO2 cryotherapy and focused shockwave therapy of the articular capsule and the periarticular fascia insertions as well as any relevant trigger points are an important foundation for practically every treatment of osteoarthritis. For intra-articular pathologies we favour the combination of PRP and hyaluronic acid.

Our experience shows first that an intensive treatment block, initially with treatment twice a week to begin with, is beneficial, and second that cryo- and laser treatment of the soft tissues often brings rapid pain relief while EMTT for the treatment of bony stress reaction often needs 3 – 4 treatments to achieve significant reduction in pain. Furthermore, in our view it is often very important to treat the surrounding myofascial structures and the muscles in the entire chain. Overall, the combination of various regenerative procedures with synergistic effects has proved to be most effective for the treatment of activated osteoarthritis in our daily practice. By these means we achieve rapid and long-lasting pain relief for the patient even without using corticosteroids and, apart from the risk of occasional initial aggravation for 1 – 3 days, they have an excellent side-effect and risk profile.

OSTEITIS PUBIS AND BONE MARROW OEDEMA

Presentation of a holistic treatment approach

THOMAS MAIER / TMPHYSIO MÜHLENINSEL, LANDSHUT

Osteitis pubis, a clinical picture that is frequently described in sports medicine and gynaecology, is usually complex for the practitioner/therapist. Exercise-induced groin pain often limits training and is very painfully tedious for athletes and active people.

One patient group consists of young football players. The onset of inflammation in the pubic rami is very often caused by muscular imbalance that develops due to one-sided training and asymmetrical loading patterns. This is compounded by hard running surfaces e.g. artificial turf pitches, and a lack of mobility and length of the muscles close to the pelvis. In a large number of treated cases, premature and excessively intensive increases in exercise lead to recurrence and protracted downtimes. Another patient group consists of postpartum women. During the pregnancy hormones cause loosening of the pelvic ligamentous structures. This laxity in the last trimester of the pregnancy provides for widening of the birth canal, thus easing the delivery process. In a physiological situation these ligamentous structures tighten again postpartum. Any disorder of tightening of the ligamentous apparatus can lead to severe protracted pain and massive restrictions in everyday living for the women affected. A history of recalcitrant and protracted pain is commonly typical in both patient groups.

Diagnostic imaging by MRI or ultrasound examination, if necessary, can confirm the diagnosis and distinguish between a number of differential diagnoses (e.g. torn adductor(s), rectus abdominis injury, inguinal hernia). A prominent feature in an MRI scan is bone marrow oedema, usually encountered bilaterally, in the pubic regions close to the symphysis. Oedematous spread is usually asymmetrical and mostly correlates with the side with more conspicuous symptoms. The so-called secondary cleft sign, the formation of an asymmetrical fissure, can often be seen within the symphysis. In many cases, poor muscular control of the local stabilisers of the lumbar spine and the hip joint as well as hypertonia, e.g. of the iliopsoas muscle, can be observed. The effects of using extracorporeal shockwave therapy to treat musculoskeletal tissue have been compiled comprehensively in a recent systematic review [1]. When treating bone, extracorporeal shockwave treatment causes activation of the stem cells, the osteoblasts. Hence radial extracorporeal shockwave therapy should be included in the holistic treatment regimen for this indication.

Showing the muscle activity with the help of electromyography (EMG) is very helpful for recognising neuromuscular activity patterns which are then applied specifically in biofeedback training. This enables the therapist and patient to objectify and feel how the specific target musculature is optimally trained and activated. Since its start a few years ago, patients can access training plans based on an app to accompany the therapy process and promote the patient's autonomous training. This way the physiotherapist/trainer can draw up the individual exercise programme and forward it with an app to the patient who, in turn, documents his/her training including the course of the pain.

FIG. 1 Treatment of bone marrow oedema/pubic bone. Handpiece is held/guided by the patient's fingers.

FIG. 2 Activation of the internal oblique muscles on both sides. Biofeedback training with specific muscle activity using the EMG readout.

CASE REPORT

The [female] patient, 32, athletic with persisting and chronic progressive pain in the region of the symphysis with increased radiation into the left groin presented at the practice. The pain began in the last third of her pregnancy, but these pains have now been constant for 1.5 years and limit all activities of daily life. Over the course of time she had tried several classic physiotherapy approaches and treatment, all of which, however, resulted in brief improvement at most. As soon as she increased the intensity of her activity and training in the past the pain reoccurred very severely. For his diagnosis the attending physician had ordered another MRI examination which, compared with the previous examination, showed spread of the bone marrow oedema on both sides, and the left ramus of the pubic bone was clearly more conspicuous. During the gait analysis at the baseline examination the patient showed considerably shortened step length on the left and an increase in the stride width. During the standing examination the lordosis of the lumbar spine was seen to be very pronounced, which was associated with poor activity of the anterior musculature. Her left-sided pain could be provoked by her standing on one leg. The Thomas test was conspicuous on both sides. The manual therapy examination of the lumbar spine and the hip joint was inconspicuous and was not connected with her pain.

TREATMENT PROTOCOL

DAY 1: TREATMENT 1

» Radial ESWT (Electro Medical System, Swiss Dolorclast Evoblue, Nyon – 25 Hz; 1.4 bar; 1.5 cm handpiece; 3000 impulses targeted at the region of the bone marrow oedema)
» Myofascial treatment of the iliopsoas muscle.

DAY 5: TREATMENT 2

» radial ESWT (25 Hz; 1.8 bar 4500 impulses)
» Myofascial treatment of the iliopsoas muscle.
» Training programme drawn up (App: Lanista Athlet, MP Sports Coaching & Consulting GmbH, Munich) – bridging on both sides, squats, segmental pelvic movements sitting.

DAY 9: TREATMENT 3

» Pain-free in everyday living since second treatment; step length and stride width normal
» Radial ESWT (25 Hz; 2.6 bar 5000 impulses)
» Biofeedback Training (EMG System, Menios GmbH, Ratingen) local stabilisers (multifidi, int./ext. obliques).
» Expanded training programme – activation of the local stabilisers incl. pelvic floor in diverse functional starting positions.

DAY 21: TREATMENT 4

» Radial ESWT (25 Hz; 2.7 bar 5000 impulses)
» Biofeedback training of the local stabilisers with dynamic asymmetric exercises (single-legged squats, standing balance exercise, side lunge)
» Expanded training programme – asymmetrical exercises, some dynamic
» MRI check-up before treatment 5: "Complete regression of the bone marrow oedema in the pubic bone on both sides, no evidence of any other pathological conditions in the region examined".

DAY 48: TREATMENT 5

» Radial ESWT (25 Hz; 2.7 bar 4500 impulses)
» Biofeedback training of local stabilisers when jumping (two-legged, one-legged short distance)
» Exercise programme drawn up with the training objective of 30 min. pain-free jogging

THOMAS MAIER

is a physiotherapist, OMPT-DVMT| HP-PT and internationally acknowledged manual therapist (IFOMPT) with his own practice in Landshut (TMPHYSIO Mühleninsel).

SUMMARY

With the help of radial shockwave therapy the patient was quickly relieved of her chronic progressive pain. Thus, the new radiology appointment showed complete resolution of the bone marrow oedema. The possibility of using EMG in the biofeedback training resulted in effective and targeted training. By using digital training planning the patient was able to work on her muscular deficits autonomously under ongoing checks by the physiotherapists. The patient's motivation and compliance were positively supported by these digital checks on her training results. However, the research carried out for this article has also showed that there are as yet no generally valid training protocols for this indication, and that training very often depends on the practical experience of the therapist/trainer. Further sports/physiotherapy studies/training protocols would be helpful for this.

The literature can be found at the Article on www.sportaerztezeitung.com

OSTEOARTHRITIS OF THE KNEE – PRP

European consensus of the ESSKA

PROF. THOMAS TISCHER, MD /
DEPARTMENT FOR ORTHOPAEDICS AND TRAUMATOLOGY,
MALTESER WALDKRANKENHAUS ST. MARIEN, ERLANGEN

The injection of platelet-rich plasma (PRP) for osteoarthritis of the knee is repeatedly the subject of controversial debate. Thus the objective of the ESSKA (European Society of Sports Traumatology, Knee Surgery & Arthroscopy) was to draw up a European consensus on the use of PRP for osteoarthritis of the knee.

To this end the current scientific literature was analysed and combined with expert opinion to formulate informative statements on the use of PRP. We used a precise methodical procedure based on a modified Delphi process (scientific adviser Philippe Beaufils, France). Under the leadership of Laura de Girolamo (Italy) and Lior Laver (Israel) a steering group (12 specialists from 9 European countries) formulated questions and answers based on the literature search on the subject areas 1) PRP – Rationale and Indication, 2) PRP – Preparation and Characterisation, and 3) PRP – Protocol. The questions were then evaluated in a two-stage process by another rating group (22 specialists) until consensus was reached. In the concluding stage a third group reviewed the geographic adaptation to the various European countries. After this complex process a total of 28 questions and answers, including an overview of the literature, were drawn up. The discussions included questions such as the dependence on the degree of osteoarthritis, the age of the patients, use during the inflammatory phase, preventive use, a comparison with corticosteroids or hyaluronic acid, the superiority of leucocyte-rich or leucocyte-poor PRP, and many others. The original version of the most important statement on the clinical evidence on the use of PRP is cited here.

PROF. THOMAS TISCHER, MD

is a specialist in orthopaedics and traumatology with additional qualifications including sports medicine and special orthopaedic surgery. He is head of the department of orthopaedics and traumatology, Malteser Waldkrankenhaus St. Marien, Erlangen. Professor Tischer is also president of the German Society of Orthopaedics and Traumatic Sports Medicine (GOTS).

QUESTION 1

Does current clinical evidence support the use of PRP for knee OA?

Statement: Clinical evidence confirms the efficacy of PRP in the treatment of knee osteoarthritis (OA). Level I and II clinical studies, as well as additional prospective studies, support the safety and clinical benefit of PRP for knee OA, which was shown in comparison to both placebo (saline) and control treatments such as hyaluronic acid or corticosteroids (CS). The efficacy of PRP in the treatment of knee OA has been also supported by meta-analyses and confirms the findings of preclinical research. The consensus group can therefore conclude that there is enough preclinical and clinical evidence to recommend/support the use of PRP in knee OA (see following questions addressing PRP specifications and indications).

The answer is based on 5 meta-analyses, one RCT, and one systematic review. The complete consensus can be downloaded free of charge from the homepage of the ESSKA (https://www.esska.org/page/Projects).

Chairpersons: Laura de Girolamo, Lior Laver / **STEERING AND LITERATURE GROUP MEMBERS:** Philippe Beaufils (France) – ESSKA Consensus Projects Advisor, Mikel Sanchez (Spain), Giuseppe Filardo (Italy), Ramon Cugat (Spain), Thomas Tischer (Germany), Jeremy Magalon (France), Rodica Marinescu (Romania), Marko Ostojic (Bosnia), Ferran Abat (Spain), Elizaveta Kon (Italy), Ricardo Bastos (Portugal), Baris Kocaoglu (Turkey), Michael Iosifidis (Greece)

MECHANISM OF ACTION OF EXTRACORPOREAL SHOCKWAVE THERAPY

A Systematic Review

TOBIAS WÜRFEL, PROF. CHRISTOPH SCHMITZ MD, LEON JOKINEN /
EXTRACORPOREAL SHOCKWAVE RESEARCH UNIT,
CHAIR OF NEUROANATOMY, INSTITUTE OF ANATOMY,
FACULTY OF MEDICINE, LUDWIG-MAXIMILIANS-UNIVERSITY OF MUNICH

In recent years, the importance of Extracorporeal Shockwave Therapy (ESWT) in the conservative treatment of musculoskeletal disorders has been continuously increasing. Especially in sports injuries, such as muscle and tendon injuries, ESWT is now often part of the standard therapy protocol.

To date, the principles of action of ESWT are poorly understood and the success of therapy frequently lacks adequate pathophysiological explanation. Numerous studies on different mechanisms of action have now been published, but there is a deficiency of scientific consensus on the effects in the respective indications of ESWT. The aim of our research group was to develop a concept on the biophysical effects of ESWT on musculoskeletal tissue based on current scientific knowledge.

METHODS

We performed a Systematic Review in the literature databases "PubMed" as well as "Web of Science" with the keywords "shock wave OR shock waves OR shockwave OR shockwaves NOT urol* NOT stone NOT review NOT clinical trial" at the cutoff date of September 30, 2021 according to the PRISMA guidelines. By reading the titles and abstracts of the papers, relevant basic science studies on mechanisms of action of ESWT were identified. In the systematic review, 181 different trials were divided into three different groups and then analyzed. The groups referred to the effect of the different target tissues of ESWT: "cartilage and bone" (100 included studies), "muscle / nerve tissue" (42 included studies) and "connective tissue" (39 included studies).

RESULTS

Analysis of the studies reviewed showed heterogeneity of studies with numerous changes at the cellular level due to shock wave therapy. Ultimately, 10 key messages could be formulated through our systematic analysis: (1) Compared to the effects of many other forms of therapy, the clinical benefit of extracorporeal shock wave therapy does not appear to be based on a single mechanism. (2) Different tissues respond to the same mechanical stimulus in different ways. (3) Just because a mechanism of action of extracorporeal shock wave therapy was described in a study does not automatically mean that this mechanism was relevant to the observed clinical effect. (4) Focused and radial extracorporeal shock wave therapy seem to act in a similar way. (5) Extracorporeal shock wave therapy stimulates both progenitor and differentiated cells, and has positive effects on pathologies of bone and cartilage. (6) Extracorporeal shock wave therapy apparently mimics the effect of capsaicin by reducing substance-P concentration. (7) Extracorporeal shock wave therapy apparently mimics effects of injection of Botulinum toxin A by destroying endplates in the neuromuscular junction. (8) Extracorporeal shock wave therapy apparently imitates certain mechanisms of action of neural therapy. (9) Extracorporeal shock wave therapy apparently imitates certain mechanisms of manual therapy treatments. (10) Even the most sophisticated research into the effects of exposure of musculoskeletal tissue to extracorporeal shock waves cannot substitute clinical research in order to determine the optimum intensity, treatment frequency and localization of extracorporeal shock wave therapy.

CONCLUSIONS

Our result suggests that mainly the cumulative effect of multiple effects explain the ESWT clinical success. The various effects on the musculature show that it is not only the treatment of the structural damage of the underlying musculoskeletal pathology that is successful. The therapeutic outcome can be presumably achieved by treating the muscular imbalances underlying the disorder and the pain aggravating myofascial trigger points. In order to establish the ideal treatment intensity, frequency and localization for the respective indication, further clinical studies will be necessary in the future.

References

Wuerfel T, Schmitz C, Jokinen LLJ. The Effects of the Exposure of Musculoskeletal Tissue to Extracorporeal Shock Waves. Biomedicines. 2022; 10(5):1084.

Tobias Wuerfel will give a lecture on this at the Isokinetic Conference 2023 in London.

THERMOGRAPHY PLUS DIAGNOSTIC EMG

Use in recurrent Achilles tendon symptoms

PROF. OLIVER TOBOLSKI, MD /
MEDICAL DIRECTOR SPORTHOMEDIC, COLOGNE

Diagnostic thermography has now achieved a relevant status for assessing functional symptoms in sports orthopaedics. Trigger points are readily shown with the help of thermal imaging cameras, especially chronified functional symptoms in the entire axial skeleton, and corresponding therapeutic measures such as shock wave treatments, dry needling, cryotherapy, friction massage or taping can be started and their success monitored in the course of treatment.

FIG. 1 Thermal imaging camera

With the infrared thermography we use (FLIR E75 thermal imaging camera, Fig. 1) the camera displays more than 75,000 measured positions with a thermal sensitivity of <0.04 degrees temperature difference, and thus it can reliably demonstrate even small areas of hyperaemia (trigger points). We can differentiate between active myofascial trigger points which are often extremely painful and frequently weaken the affected muscle, latent myofascial trigger points which are only painful on movement, and associated trigger points which develop due to functional disorders of neighbouring muscle groups. More recently, differentiated EMG investigations are being used increasingly in conjunction with thermography to identify problems with efferent signals to the musculature in parallel, and to correct these with the help of biofeedback training. Initially thermography was mainly used for muscles close to the vertebral column to identify painful muscular tension in the lumbar and cervical spine and to work specifically on these structures. In the present case the indication for diagnostic thermography has been extended to Achilles tendon symptoms.

CASE STUDY

We were consulted by a 29-year-old [female] patient with recurrent symptoms at the myotendinous junction of the right Achilles tendon, particularly one day after sporting activity (running). Her average training schedule was 40 – 50 km/week, she could not remember having had an accident. The diagnostic imaging we performed (ultrasound, MRI) and differentiated foot pressure measurements ruled out any structural changes in the tendon and any relevant foot deformities. Only the ultrasonography on the day after sporting activity showed peritendinitis in the proximal part of the tendon. The subsequent EMG of the gastrocnemius muscle showed an increased resting tone of the right gastrocnemius. Further functional diagnostics (neuromuscular activation) showed a reduced efferent supply to the medial calf muscles (Figs. 2 & 3).

The thermography carried out in parallel impressively showed a painful area in the proximal region of the right Achilles tendon (Figs. 4 & 5). In addition to (focused) shockwave therapy the patient was treated with laser therapy and neuroreflex cryotherapy of the proximal Achilles tendon origin with taping of the muscle and (later) adjunctive biofeedback training of the calf muscles (Figs. 6 – 10).

FIG. 2 Dynamic EMG measurement of gastrocnemius (resting tone and activation increased on the right)

FIG. 3 EMG measurements on uneven ground (neuromuscular activation)

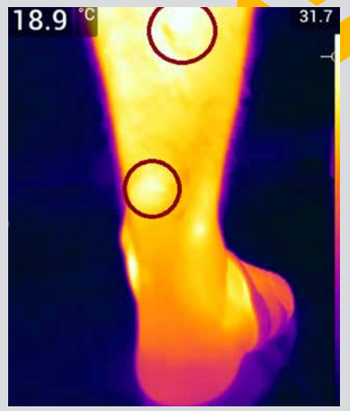


FIG. 4 Thermography showing several trigger points, both at the myotendinous junction and in the muscle belly of the gastrocnemius muscle, see circles

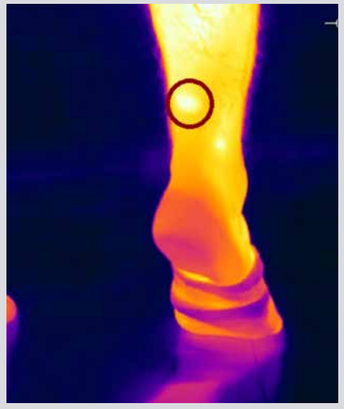


FIG. 5 Thermographic image of the calf in plantar flexion with clear evidence of the trigger point, see circle

FIG. 6 Neuroreflex cryotherapy of the tendon

FIG. 7 Focused shockwave treatment of the trigger points

FIG. 8 Laser treatment of the Achilles tendons

FIG. 9 Applying tape

FIG. 10 EMG-guided biofeedback training of the calf muscles

PROF. OLIVER TOBOLSKI , MD

is the Medical Director of Sporthomedic, Sportorthopädische Praxisklinik Cologne, official medical centre of the Olympic Centre Rhineland. He is a specialist for surgery with additional qualifications in sports medicine and chirotherapy. Prof. Tobolski is also the team physician of the Middle Rhine Tennis Association and an ATP tournament doctor.

The follow-up examinations showed a marked reduction in trigger point formation over the proximal Achilles tendon, even after the first treatment session. After two sessions of shockwave therapy plus taping and two sessions of biofeedback training the patient was clinically 100% symptom-free (Figs. 11 – 13).

SUMMARY

Thermography impressively helps diagnose muscular trigger points and monitor successful treatment, particularly of functional symptoms, including those in the tendinous origins distant from the spine. Secondary muscle dysfunction is demonstrated by EMG and treated using EMG-based biofeedback therapy.

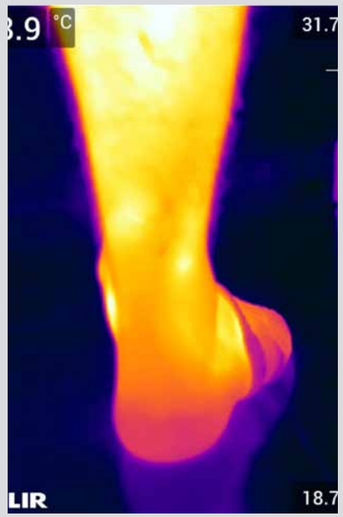


FIG. 11 Regression of trigger point formation at the myotendinous junction (after 1 treatment)

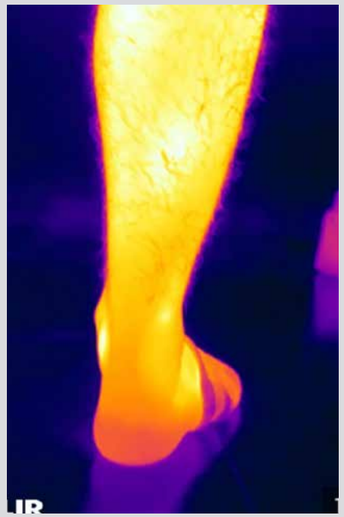


FIG. 12 Virtually complete regression of the trigger point in the thermography (after 3rd treatment)

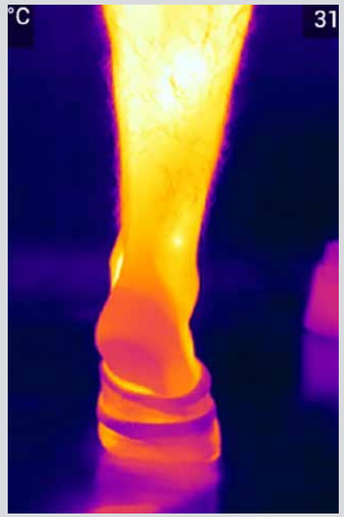
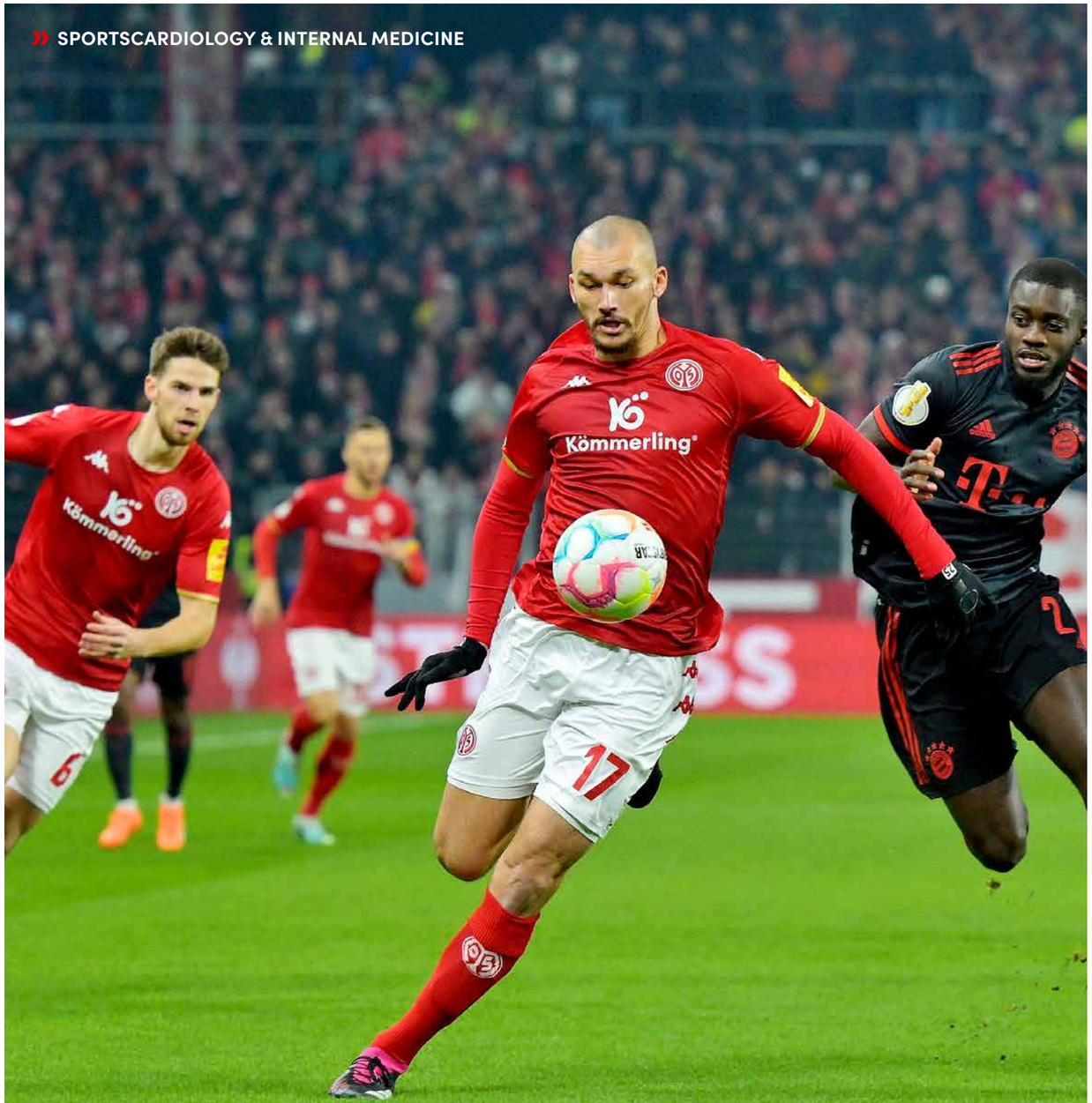


FIG. 13 Complete regression of the trigger point, also on exertion (plantar flexion)



RETURN TO PLAY AFTER INFECTIONS

The role of the orthostatic test

ALEXANDER R. TAMM MD[1,2], SIMON DIESTELMEIER MD[1]
[1]CENTRE FOR CARDIOLOGY / UNIVERSITY HOSPITAL, JOHANNES GUTENBERG UNIVERSITY MAINZ
[2]CARDIOLOGY AT MAINZ MITTE HEALTH CENTRE

Due to their prevalence of about three episodes a year and a mean duration of five days [1], infections of the upper respiratory tract and potential complications such as myocarditis and an increased risk of muscular injuries are of special significance for athletes. This drew particularly widespread attention in association with the COVID-19 infection, but it also applies to influenza and other viral airways infections.

Initially there were few recommendations for returning to play after infections of the upper airways [2]. As the focus narrowed on the COVID-19 pandemic, recommendations on returning to sporting activities were published that were in line with the changes in the virus variants themselves [3 – 5]. Besides the individual course of viral infections, individual assessment is equally important, especially for elite athletes due to the usually more rapid resumption of training or even competitive sports. Medical evaluation in such cases poses a priority conflict between the athlete's primary welfare and the aim of enabling the athlete to resume sports as quickly as possible.

MONITORING HRV & ORTHOSTATIC TESTING

Monitoring heart rate variability (HRV) and performing an orthostatic test can serve as additional parameters for this. Since these measurements are often routinely carried out in top athletes anyway when deciding on the intensity of training, individual reference parameters for each athlete are available for comparison. The normal course of heart rate after orthostasis is as follows: the resting rate is followed by an initial rapid compensatory increase in heart rate followed by counter-regulation and a subsequent plateau compared with the supine resting heart rate, and a slightly higher heart rate when standing. The changes in heart rate and the HRV reflect changes in the autonomic nervous system. Infections are usually associated with increased heart rate at rest, with limited HRV and particularly with a higher peak of the maximum heart rate. Furthermore, there is only little counter-regulation of the heart rate, if any, when standing. Experience with SARS-CoV-2 infections showed deviations from this, often with an unchanged or even lower resting heart rate and considerably limited HRV. Nevertheless, the peak is higher after standing up, the higher heart rate persists, and there is a sharp drop in HRV [6].

Photo: © IMAGO Images / MIS

FIG. 1 Orthostatic test during routine recovery
Heart rate at rest 50/min, HRV at rest 72 ms, peak heart rate 85/min, heart rate standing 70/min, HRV standing 16 ms

FIG. 2 Orthostatic test at the beginning of the infection (day 1)
Heart rate at rest 72/min, HRV at rest 34 ms, peak heart rate 110/min, heart rate standing 111/min, HRV standing 2 ms

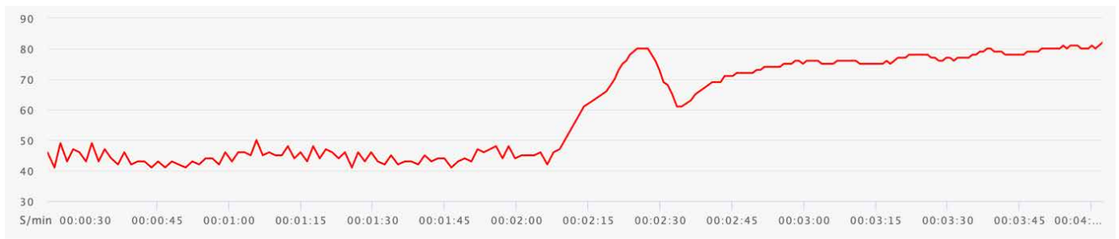


FIG. 3 Orthostatic during the course of the infection (day 3)
Heart rate at rest 45/min, HRV at rest 82 ms, peak heart rate 80/min, heart rate standing 80/min, HRV standing 4 ms

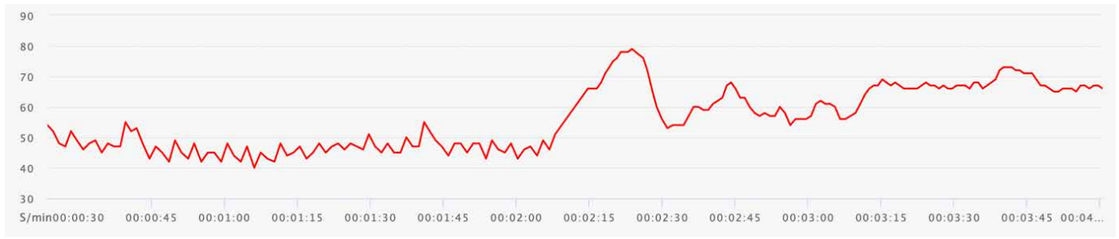


FIG. 4 Orthostatic test at the end of the infection (day 6)
Heart rate at rest 46/min, HRV at rest 97 ms, peak heart rate 78/min, heart rate standing 65/min, HRV standing 19 ms

ALEXANDER R. TAMM, MD

is a specialist for internal medicine and cardiology with additional qualifications in sports medicine/sports cardiology. He is chief consultant for interventional heart valve therapy at Mainz University Medical Centre and internistic team doctor of 1 FSV Mainz 05.

SIMON DIESTELMEIER, MD

is a specialist for internal medicine with an additional qualification in sports cardiology. He is chief consultant for preventive cardiology at Mainz University Medical Centre and internistic team doctor of 1 FSV Mainz 05.

CASE STUDY PROFESSIONAL FOOTBALL PLAYER

In addition to clinical evaluation we use the orthostatic test intensively in competitive sports to guide individual intensification of training during infections. We present the case of a professional football player with a SARS-CoV-2 infection as an example of this. The reference was a routine orthostatic test (Vantage V2 Sports Watch, Polar Electro) with the athlete's normal supine HRV and good counter-regulation after standing up (Fig. 1). During the early phase of the infection this showed a higher heart rate at rest with limited HRV and the absence of any counter-regulation after standing up (Fig. 2). During this phase no sporting exertion can be recommended as this may prolong the infection with potential long-term complications. During the further course of the infection when heart rate is lower and supine HRV is better there is minor counter-regulation after standing up although heart rate is higher and increases further over time, and HRV is lower (Fig. 3). At this point in time gentle aerobic training can be started. Daily monitoring and clinical parameters decide on further intensification of training. After recovery from the infection the plot is seen to be similar to the baseline condition again (Fig. 4) with good autonomic counter-regulation. Anaerobic training is possible again. Depending on the severity of the infection, regardless of the pathogen, we recommend sports cardiology diagnostic investigations with a clinical examination, laboratory tests and echocardiography before approving competitive sports.

SUMMARY

Measuring HRV and performing an orthostatic test are simple additional methods for evaluating the resumption of sporting activities after infections. During viral infections these show an increased heart rate at rest and, particularly, a marked increase in heart rate after standing up. HRV decreases markedly in both cases. Besides established clinical parameters, evaluation of heart rate in the orthostatic test together with HRV can be an additional tool for evaluating return to play.

The literature can be found at the Article on www.sportaerztezeitung.com

MINCED CARTILAGE IMPLANTATION

Promising method for one-step cartilage regeneration

Photo: © IMAGO Images / Hartenfelser

JAKOB HAX MD, PROF. GIAN SALZMANN MD,
DEPARTMENT OF HIP AND KNEE SURGERY / SCHULTHESS KLINIK, ZURICH

ASSOC. PROF. ARMIN RUNER MD /
DEPARTMENT OF SPORTS ORTHOPAEDICS,
KLINIKUM RECHTS DER ISAR, MUNICH TECHNICAL UNIVERSITY

The incidence of chondral and osteochondral defects is increasing due to the raised activity profile of the population and modern, continually improving MRI diagnostic methods. The incidence of cartilaginous defects in the knee among athletes is given as up to 36 % [13].

Untreated lesions cause higher mechanical loading of the surrounding intact cartilage [9, 16, 18] and have an effect on the subchondral bone [27] and on the intra-artikular mlieu, with an increase of cytokine concentration [14] and thus a premature onset of osteoarthritis. This not only limits the patients' function, but also causes considerable costs to the public health system. Thus, suitable cartilage reconstruction techniques with the specific regeneration of hyaline- or hyaline-like cartilage are required. A number of different surgical procedures are already available for the treatment of focal chondral lesions, including techniques like bone marrow stimulation (microfracture (MFx), autologous matrix-induced chondrogenesis (AMIC)), osteochondral auto- or allograft transplantation surgery (OATS), and autologous chondrocyte implantation (ACI) [5, 11 – 13, 33]. Since each of these techniques has pros and cons, the treatment of chondral lesions has not been standardised and remains a challenge.

ACI is currently seen as the treatment of choice for moderate to large chondral defects, since this procedure leads to hyaline- or hyaline-like cartilage substance with good long-term clinical outcomes [6, 7, 15, 17, 28]. The disadvantages of ACI are the high laboratory costs for cell expansion, limited availability in some cases, and the need for two-step surgical procedures [5, 12, 32]. In order to overcome these disadvantages, one-step procedures such as the implantation of fragmented autologous or allogenic cartilage have been developed (Minced Cartilage Implantation (MCI)). The underlying principle was already described in the early 1980s by Albrecht et al. [1, 2] and picked up again by Lu et al. in 2006 [22]. Over the past few years interest in MCI has grown considerably especially due to several advantages, such as being a single stage procedure that can be performed in an arthroscopic or mini-arthrotomy surgical approach and may offer strong biologic potential [5, 32].

BIOLOGY

In their in vivo milieu chondrocytes have the potential to proliferate physiologically [3, 32]. Furthermore, mechanical stimuli play an important role in chondrocyte proliferation and chondrogenic differentiation [36, 37]. This complex biochemical and biomechanical intra-articular milieu, that can barely be reproduced in vitro, could be a major advantage regarding the biological potential of the MCI procedure. It has been shown that mincing healthy cartilage "activates" the chondrocytes and leads to a physiological reaction with chondrogenic proliferation and the production of extracellular matrix (ECM) [22 – 24, 32]. Mincing can be achieved with a scalpel, specially developed mincing devices, or arthroscopic shavers [19, 20, 32]. The cartilage is harvested from the margins of the chondral defect or from zones of the joint that are subjected to less loading. The outgrowth of activated chondrycytes is promoted by this enlargement of the tissue surface [4, 5, 20, 22, 32]. Ultimately this leads to the regeneration of hyaline and/or hyaline-like cartilage [22, 32, 35].

SURGICAL TECHNIQUE

The preoperative planning of a chondroplasty procedure includes a mandatory MRI and conventional radiographs (whole-leg) [31] to detect and treat any comorbidities such as ligamentous instability, meniscus defects or mechanical axial malalignment. The final planning of the chondroplasty is only completed following detailed arthroscopic diagnostic investigation of the defect. The cartilage can then be harvested with osteochondral cylinders from zones that are barely load-bearing (e.g. the intercondylar notch), or using ring curettes and shavers [31, 33]. When using osteochondral cylinders the cartilage must be separated from the bone and then minced with a scalpel or shaver until it has reached a paste-like consistency. During arthroscopic cartilage harvesting this is done exclusively with a shaver [33]. After preparing the defect and creating stable cartilage margins the joint is aspirated, the defect zone is dried, and the minced cartilage is introduced into the defect. Depending on the technique being used, autologous thrombin and PRP, fibrin glue and/or a membrane are used for stable fixation of the fragments [25, 26, 31 – 33].

CLINICAL DATA

Clinical evidence on autologous MCI is still limited [8, 10, 25]. In 2015, Christensen et al. [8] treated eight patients with osteochondrosis dissecans of the knee joint with a combination of autologous bone graft and autologous cartilage fragments embedded in fibrin glue (autologous dual-tissue transplantation (ADTT)). One year later there was a marked improvement in the

MOCART score (Magnetic Resonance Observation of Cartilage Repair Tissue) from 22 to 52 points. In 2019, Massen et al. [25] conducted a consecutive two-year study of patients with (osteo-) chondral lesions who had been treated with autologous MCI. At the final follow-up examination a significant reduction in pain was observed. Moreover, a significant radiological improvement in the MOCART score was seen. In 2020, Cugat et al. [10] treated 15 patients with full-surface (osteo-)chondral lesions using autologous MCI embedded in platelet-poor plasma (PPP) and PRP. After 15 months they also observed statistically significantly better scores on the visual analogue scale (VAS) for pain, the Lysholm score, the subjective International Knee Documentation Committee (IKDC) score, the Western Ontario and the McMaster Universities Osteoarthritis Index (WOMAC) for pain and function, the Lequesne-Index and the Short Form 12 (SF-12). While the above-named clinical studies were conducted on the knee joint, autologous MCI is also used in other joints (hip, shoulder, ankle) [21, 29, 30, 34]. In summary it may be said that the clinical data to date show good results with low complication and revision rates which are comparable to other cartilage repair techniques (ACI).

CASE STUDY

A 37-year-old patient, an active sportsman, consulted us after multiple left knee sprains; first sprain in 2005. Since then intermittent symptoms in the left knee joint, prone to swell. The clinical examination showed articular effusion with pain on pressure over the medial joint space and mild crepitation in the medial compartment when testing movement, ROM extension/flexion 3-0-145° pain-free. Joint with stable ligaments. The Knee Injury and Osteoarthritis Outcome Score (KOOS) for pain was 50 before surgery, the quality of life score for the knee was 25 points, and 44 for activities of daily living (0 = extreme knee problems, 100 = no knee-related impairment). The Marx activity rating scale (MARS) was initially 0 points (0 = lowest physical and sporting activity, 16 = highest physical and sporting activity). The MRI showed grade 4 cartilage damage over the medial femoral condyle (Fig. 1). The preoperative AMADEUS score for the medial cartilage lesion was 60 points. Minced cartilage implantation was indicated.

The arthroscopic operation with the implantation of minced cartilage in the medial femoral condyle using the product Autocart (Arthrex) was performed. During the operation we diagnosed a 3 cm² ICRS grade 3B chondral lesion over the medial femoral condyle (Fig. 2). The postoperative course was complication-free. Follow-up treatment consisted of six weeks' partial 15 kg weight-bearing on the left. The range of motion was limited to 60° for weeks one, two and three, and to 90° for weeks four, five and six. The patient was initially splinted with a Mecron brace, which was replaced with a rigid frame brace in the later course. He had physiotherapy for three months after surgery. At the check-up two months after surgery he still had some residual symptoms with a ROM in extension/flexion of 0-0-90° and his quadriceps muscles were still weakened.

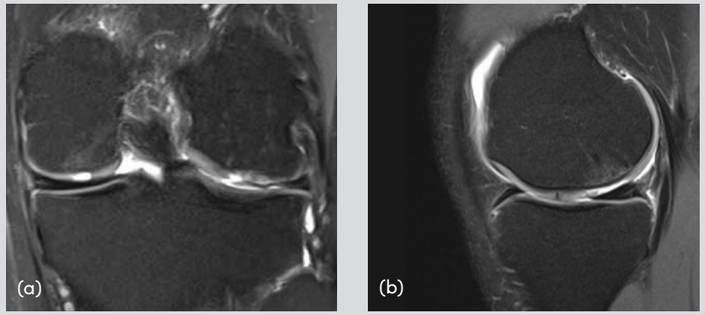


FIG. 1 MRI of left knee before surgery with visible cartilage damage over the medial femoral condyle in the coronal plane (a) and the sagittal plane (b).

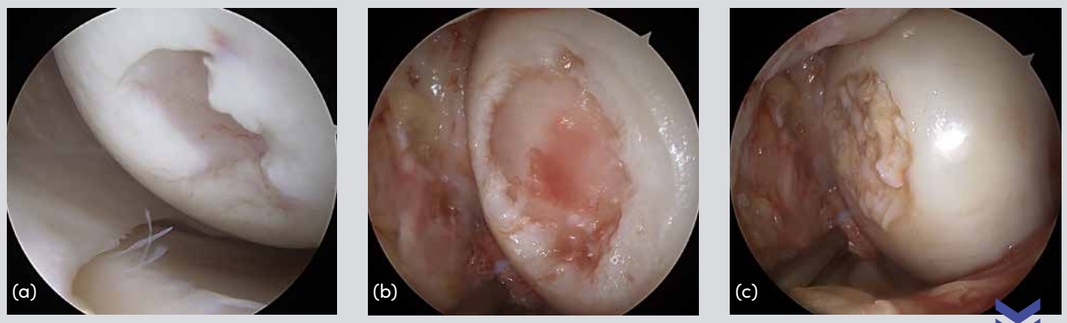


FIG. 2 Intra-operative arthroscopic images showing the untreated cartilage damage (a) and the lesion after preparation of stable cartilage margins (b) and implantation of the minced cartilage (c).

JAKOB HAX, MD

is a specialist trainee in the department of hip and knee surgery at the Schulthess Klinik in Zurich. His research work focuses on hip and knee surgery, joint-sparing surgery and joint reconstruction. His specialities are sports orthopaedics/ traumatology and cartilage reconstruction.

PROF. GIAN SALZMANNM, MD

is a specialist in orthopaedic and accident surgery. He holds a university teaching position at the faculty of medicine at Freiburg University. His specialty is knee surgery. He is a partner at the Gelenkzentrum Rhein-Main and Senior Consultant at the knee surgery section at the Schulthess Klinik in Zurich. He is also an AGA instructor and medical advisor for Eintracht Frankfurt football club.

ASSOC. PROF. ARMIN RUNER, MD

is a specialist trainee for accident surgery and orthopaedics at the section for sports orthopaedics, Klinikum rechts der Isar, Munich Technical University. He is also team doctor for HC Innsbruck – Die Haie (ice hockey) and the Italian national fistball team.

After eight months the patient then reported a satisfactory surgical outcome with improved movement and a clinically irritation-free knee joint. One year after surgery the patient was still satisfied and was able to re-initiate low-impact sporting activities (cycling). After two years the patient had reached his regular everyday level, and intensification of sporting activities in the low-impact range was possible. The clinical outcome parameters showed an improvement in the KOOS score for pain (from 50 to 53 points), knee-related quality of life (from 25 to 38 points) and activities of daily living (from 44 to 71 points). The MARS had also increased from 0 points before the operation to 6 points afterwards. The MRI two years after surgery showed a corresponding satisfactory outcome with a MOCART score of 95 points (Fig. 3).

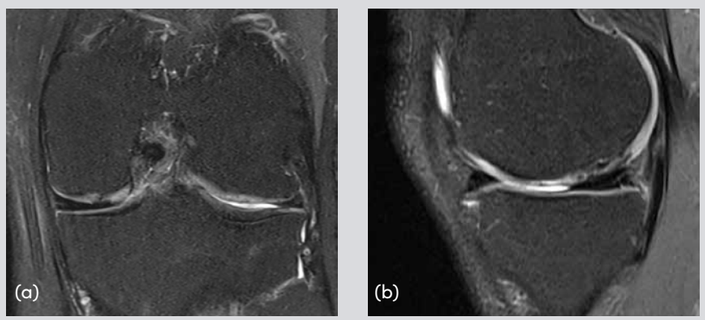


FIG. 3 MRI of the left knee two years after surgery following minced cartilage implantation at the medial femoral condyle in the coronal plane (a) and the sagittal plane (b).

SUMMARY AND OUTLOOK

On the basis of the available in vitro and in vivo data, autologous MCI is a promising one-step chondral repair procedure with great biological and clinical potential. Further medium- to long-term comparative studies on large patient cohorts with clinical, functional and radiological data are required to determine the optimal defect size for MCI and the durability of the repair cartilage, and to enable comparison with other, established chondral repair procedures.

The literature can be found at the Article on www.sportaerztezeitung.com

READ FOR YOU BY MR SEBASTIAN KUNZ

The burden of hamstring injuries in professional footballers

Jan Ekstrand, Håkan Bengtsson, Markus Waldén, Michael Davison, Karim M Khan, Martin Hägglu, http://dx.doi.org/10.1136/bjsports-2021-105407

The recently published paper from Ekstrand et al. describes the incidence of hamstring injuries in male professional football players over consecutive 21 seasons (2001/02 to 2021/22). The authors also analyse the time trends of hamstring muscle injuries over the most recent eight seasons (2014/15 to 2021/22) and in addition, they outline hamstring injury location, mechanism and recurrence rate.

Data was collected from the Elite Club Injury Study (ECIS). The individual player exposure and the time-loss injuries of 3909 players were recorded by the medical staff of 54 football teams from 20 European countries, which all qualified for the UEFA Champions League (UCL) group stage.

A hamstring injury was defined as a 'complaint sustained by a player that resulted from a football match or football training and led to the player being unable to take full part in future football training or match play'. In the beginning injuries were solely classified by using the Orchard Sports Injury Classification System (OSICS); however, since 2011/12 the Munich Muscle Injury Classification was also used to classify hamstring injuries. Between 2001/02 and 2021/22, 2636 hamstring injuries were documented representing 19 % of all reported injuries. Compared to the first recorded season, the proportion of diagnosed hamstring injuries and the proportion of all injury absence days caused by hamstring injuries have doubled by 2021/22 (from 12 % to 24 % and from 10 % to 20 % respectively). Specifically during the last 8 consecutive seasons the incidence (Number of injuries per 1000 player hours, 6,7 % annually) and the burden (Number of lay-off days per 1000 player hours, 9.0 % annually) of hamstring injuries during training and match play have increased significantly. The hamstring injury incidence was 10 times higher during match play than during training and the median lay-off following a hamstring injury was 13 days. Overall it was reported that during a season 20 % of players missed training or match play due to a hamstring injury and 8 hamstring injuries can be expected in a 25-player squad per season. In addition, there were more structural than functional injuries classified, whereby these structural injuries were associated with a longer lay-off time than the functional ones (median absence 17 vs. 6 days).

In terms of the injury mechanism and location, this study confirmed the existing knowledge that sprinting was the most common mechanism and the biceps femoris injuries were more frequent than semitendinosus and semimembranosus injuries. However, further details concerning which phase of sprinting (i.e., terminal swing, early stance) or which exact part of the biceps femoris (i.e., proximal, distal, T-junction, long/ short head or myofascial, myotendinous, or tendinous) were not described. Regarding the recurrence rate, 18 % of all recorded hamstring injuries were recurrences, from which early recurrences (within 2 months) made up 69 %. Recurrences were nine times more likely to occur in matches than in training. An increased recurrence rate specifically within the first 2 months could indicate that return to full training/competition may be too early for some types of injuries. Taking into consideration that the healing time of different kind of tissues takes longer than others (i.e., connective tissue), healing may not be sufficiently completed to sustain certain thresholds of high-speed exposure. The authors hypothesize that the reason for the increasing number of hamstring injuries could be because the intensity of elite's football matches has significantly increased, which has led to more high intensity activities in professional footballers compared to the past. Another explanation may be related to a more crowded match calendar of players associated with fewer training sessions during the (pre-) season period considering that more training sessions may lower the injury risk. In summary, this publication highlights the increasing burden of hamstring injuries in elite football. More effort is needed to understand better how to prevent the first injury and how to manage injured players more effectively to reduce the risk of re-injuries.

MR SEBASTIAN KUNZ

is a consultant orthopaedic and trauma surgeon who is currently working as a club doctor at Chelsea Football Club. Prior to joining CFC, he was the medical director of Lanserhof at The Arts Club in London for over 4 years. Before moving to the UK, he worked for several years at ATOS MediaPark Klinik Cologne, MVZ Ortho Königsallee Düsseldorf, Lans Medicum Hamburg and he was a club doctor of Viktoria Köln.

Photo: © IMAGO Images / Xinhua

OVERVIEW OF THE POST FIFA WORLD CUP 2022 PLAYERS WORKLOAD REPORT

AMR FARAG, MD / DUBAI PHYSIOTHERAPY AND REHABILITATION CENTER (DPRC), DHA

FIFPRO has recently released the Player Workload report of FIFA World Cup Qatar 2022, a report analyzing the increased workload of footballers who participated at Qatar 2022. The report was mainly based on the methodology and metrics of the FIFPRO Player Workload Monitoring (PWM) platform and FIFPRO Player IQ in collaboration with Football Benchmark. The FIFA World Cup was a highly demanding tournament for the players with various factors that have aggravated the workload demands on the players to extreme levels.

INSUFFICIENT PREPARATION AND RECOVERY TIME FOR PLAYERS

The 2022 world cup was the first edition of the tournament held during the winter. Most players arrived only few days before the tournament, expected to perform at their highest level after a demanding period of club matches in their domestic leagues and continental competitions.

- Less than 50 % of players believed they had sufficient time to prepare for the 2022 FIFA World Cup, especially those whose teams progressed to at least the quarter-finals.
- 75 % of surveyed players from these teams reported inadequate time to prepare for the tournament.
- Around 68 % of the players stated that optimal preparation time should be between 14 – 21 days (Fig. 1& 2).

CONDENSED MATCH SCHEDULE RESULT IN AN INTENSE WORKLOAD ON THE PLAYERS

Due to the winter timing, the World Cup had a compressed schedule with 64 matches played in just 29 days. This put intense physical demands on players. Even with 32 participating nations, the tournament became the shortest one since the 1978 tournament which featured only 16 teams. Players at the top of the game were pushed to their limits as many of them experienced an alarming increase in their already heavy workload without having sufficient time to recover between the games (Fig. 3).

IMPACTFUL EXTENDED STOPPAGE TIME

During the World Cup, players experienced extended stoppage times as referees were instructed to follow a new interpretation. During this immensely congested schedule, this change led to several matches that were unusually long, often exceeding 100 minutes in length.

This increase in playing time may seem small, but it could have a significant impact on the players' workload, rest and recovery and conditioning. By requiring players to spend more time on the field, it could put additional strain on their bodies and potentially increase the risk of injury. If this new interpretation was adopted more widely across all competitions, players would be forced to cope with longer effective playing times amid their already overloaded match calendars. The average stoppage time was around 11.6 minutes at the 2022 tournament (excluding matches that went into extra time). This is a significant, almost 60 % increase compared to the World Cup in Russia four years prior. 53 % of surveyed players liked the new interpretation of stoppage time rules at the FIFA WORLD CUP™ but stressed that widespread adoption could be only supported if the extended playing time impact was accounted for in fixture planning.

INADEQUATE RECOVERY AND ITS IMPACT ON PLAYER'S PHYSICAL AND MENTAL HEALTH

One of the main challenges for players after the conclusion of the 2022 FIFA World Cup™ was the short turnaround between the end of the tournament and the resumption of club football. The majority of the players surveyed (61 %) indicated that they would like to have had 14 – 21 days for recovery before returning to play with their clubs. 67 % of Germany-based players felt positive about the time for recovery, as the Bundesliga resumed only in mid-January. Only 38 % of England-based players felt that they had enough time for recovery. The consistent imbalance between workload and recovery is likely to lead to increase risk of injuries, both physical and mental, to players. Mental fatigue, 20 % of players reported experiencing extremely high levels of mental or emotional fatigue at this time of the season (January) compared to usual at this point in a regular season with a further 23 % feeling more mental fatigue than usual (Fig. 4).

Physical fatigue, 44 % of players experienced extreme or increased levels of fatigue compared to how they usually feel at this time of the season (January). Unfortunately, as we have seen in the post-tournament period, this accumulated fatigue has likely contributed to a number of leading players suffering soft-tissue injuries as extreme fixture congestion

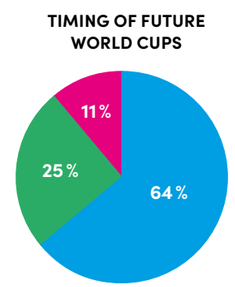


FIG. 1 Only 11 % of Players favour the November/ December Timing for the FIFA WORLD CUP™

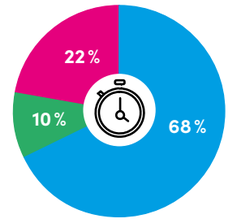


FIG. 2 FIFPRO PWM Statistical Evidence: Inadequate Preparation Time: A Cause for Concern

Source: FIFPRO PWM, Football Benchmark analysis

TOP 20 OUTFIELD PLAYERS BY MINUTES PLAYED IN 2022/23[1]
From 1st August 2022 until 1st January 2023

	Name	National Team	Club[2]	Position	Appearances made	Minutes played in all competitions	World Cup 2022 Minutes
1	N. Otamendi		SL Benfica	DF	33	3,266	796
2	E. Fernández		SL Benfica	MD	35	2,994	651
3	H. Kane		Tottenham Hotspur FC	FW	31	2,943	451
4	V. van Dijk		Liverpool FC	DF	29	2,897	543
5	K. Mbappé		Paris Saint-Germain FC	FW	31	2,847	691
6	B. Fernandes		Manchester United FC	MD	30	2,748	398
7	Z. Debast		RSC Anderlecht	DF	29	2,741	-
8	A. Hakimi		Paris Saint-Germain FC	DF	32	2,680	694
9	C. Gakpo		PSV Eindhoven	FW	30	2,664	494
10	P. Højbjerg		Tottenham Hotspur FC	MD	28	2,662	301
11	L. Messi		Paris Saint-Germain FC	FW	28	2,656	796
12	J. Bellingham		BV Borussia 09 Dortmund	MD	28	2,608	471
13	Marquinhos		Paris Saint-Germain FC	DF	29	2,582	474
14	D. Rice		West Ham United FC	MD	29	2,573	479
15	Y. Fofana		AS Monaco FC	MD	32	2,564	263
16	I. Perišić		Tottenham Hotspur FC	MD	33	2,555	728
17	Rodri		Manchester City FC	MD	28	2,543	433
18	D. Sow		Eintracht Frankfurt	MD	30	2,542	279
19	B. Xhaka		Arsenal FC	MD	29	2,540	397
20	J. Kimmich		FC Bayern München	MD	28	2,538	305

[1]Note: Total minutes include stoppage time minutes. [2]Note: The Club column shows the club the player was playing for during the analysed period. *Source: FIFPRO PWM, Football Benchmark analysis*

FIG. 3 Workload Overview: 2022/23[1]

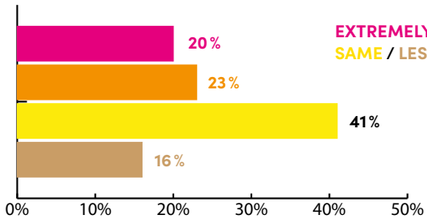


FIG. 4 Mental/ Emotional Fatique Compared to Other Seasons

AMR FARAG, MD

is Specialist Physical medicine and rehabilitation (MBBS, M.SC.) , Dubai Physiotherapy and Rehabilitation center (DPRC), Dubai health Authority. He ist Assistant lecturer Ain Shams University, Cairo, Egypt and also Member in the Egyptian Society of Physical medicine and Rehabilitation, in Emirates society of rehabilitation and sports medicine and in International Society of Physical medicine and Rehabilitation (ISPRM).

continues (Fig. 5). Injury risk, according to the FIFPRO survey, 52 % of players reported suffering an injury or feeling more susceptible to injury due to the congested schedule. Interestingly, this trend was more prominent among non-first time World Cup players, who tend to be older, more experienced, and have a better understanding of their bodies, with 75 % of them reporting such injuries or susceptibility.

Since the start of the World Cup, there have been 66 players who suffered an injury, according to media reports. This equates to approximately 8 % of all players who participated at the tournament in Qatar. These players had 76 injuries in total as some recorded more than one. It is also strongly assumed that minor injuries often go unreported, hence the actual number could even be higher.

58 % of reported injuries occurred during the World Cup, while 42 % happened after the conclusion of the tournament. Key players for both club and country such as Virgil van Dijk (Liverpool FC), Aurelien Tchouameni (Real Madrid CF), Marcelo Brozovic (FC Internazionale Milano), Angel Di María (Juventus FC) all picked up an injury very soon upon returning to their clubs (Fig. 6).

BURDEN OF PLAYER PARTICIPATION ON LEAGUES AND CLUBS

For the 2022 World Cup, 55 different leagues had at least one player at the tournament. The Premier League is the standout in this ranking: 13 players from the English top division accumulated more than 33,000 minutes during the tournament. This is almost equal to the combined record of the second and third ranked leagues (Spanish La Liga and Italian Serie A). Subsequently, this places a significant workload on players during the season. On top of to their regular workload, they were now subjected to a mid-season interruption and additional matches at the World Cup.

Clube most affected by World cup participation are Manchester city who had 16 players reached close to 5,200 combined World Cup minutes; they are followed by FC Barcelona with 4,741 minutes (17 players) and Manchester United FC with 4,364 minutes (14 players).

CONCLUSIONS OF THE FIFPRO PLAYER WORKLOAD MONITORING (PWM) REPORT

- The unprecedented winter schedule of the 2022 FIFA World Cup™ posed many challenges for players, especially concerning the short turnaround between the end of the tournament and the resumption of club football. Several players were subject to extremely limited rest and recovery times, increasing the risk of injury and hinder performance optimisation.
- 86 % of participating players want a preparation period of at least 4 days going into the World Cup, with the vast majority seeking 14 – 21.
- 52 % of players reported an injury or were concerned about the likelihood of getting injured due to the congested calendar.
- Only 11 % of players favour the November / December timing of the World Cup.
- Those Findings should be considered by the FIFA and tournament organizers in future tournaments and to be aware not only of timing and length of the tournament but also to listen to the player's voice.

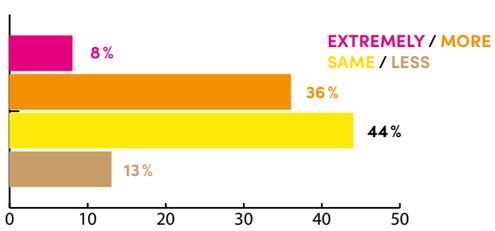


FIG. 5 Physical Fatique Compared to Other Seasons

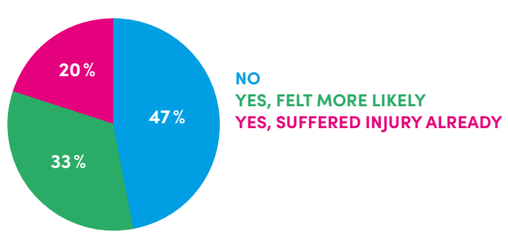
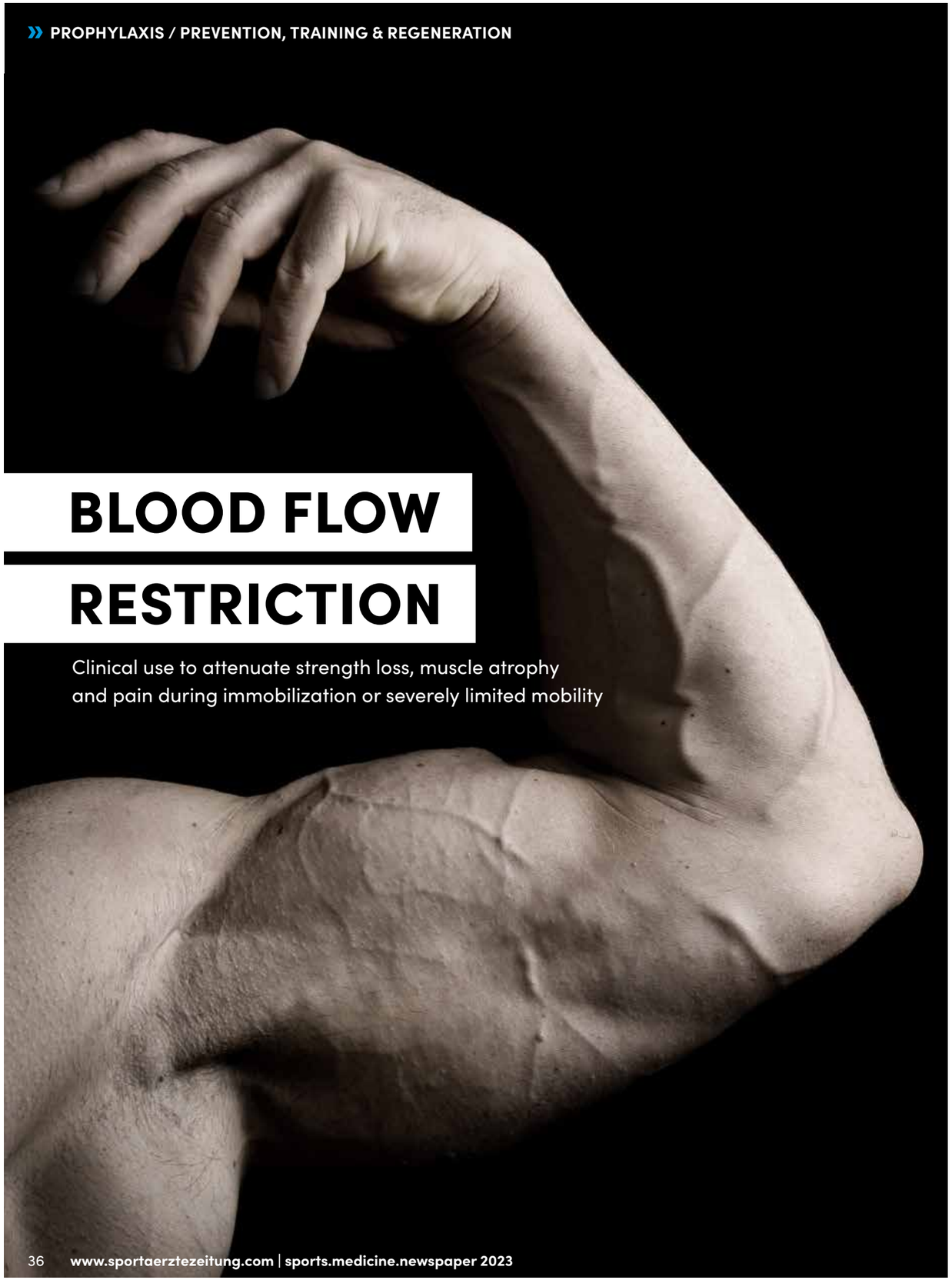


FIG. 6 Injury due to fixture calender



BLOOD FLOW RESTRICTION

Clinical use to attenuate strength loss, muscle atrophy and pain during immobilization or severely limited mobility

Photo: © istockphoto.com / softservegirl

ROBERT BIELITZKI, TOM BEHRENDT, PROF. LUTZ SCHEGA /
DEPARTMENT OF SPORT SCIENCE, OTTO-VON-GUERICKE UNIVERSITY MAGDEBURG

PROF. MICHAEL BEHRINGER MD /
DEPARTMENT OF SPORTS SCIENCES, GOETHE UNIVERSITY FRANKFURT

ALEXANDER FRANZ MD/ DEPARTMENT OF ORTHOPEDICS AND TRAUMA SURGERY,
UNIVERSITY HOSPITAL BONN

Acute severe injuries and degenerative diseases of the musculoskeletal system as well as surgical interventions are usually characterized by phases of restricted mobility with strongly reduced load-bearing capacity or complete immobility of corresponding areas [1]. This temporary or long-lasting situations are strongly associated with strength loss due to neural impairments (e.g., decline in high threshold motor unit recruitment and arthrogenic inhibition [2, 3]) and muscle atrophy (due to an imbalance in muscle protein synthesis and breakdown [3, 4]).

In the recent past, a new conservative therapy approach termed blood flow restriction (BFR) has gained great interest from scientists and therapists. BFR training describes an alternative method based on partial vascular occlusion to induce metabolic changes that allow mitigating functional and morphological degeneration or increasing muscle mass and strength by using no additional activities [5] or low mechanical loads [6], respectively. Considering these beneficial effects, BFR seems suitable after acute injuries (e.g., anterior cruciate ligament rupture) as well as for patients with degenerative diseases (e.g., gonarthrosis) or after a surgical intervention (e.g., total knee arthroplasty).

MECHANISMS OF BFR-INDUCED EFFECTS ON MUSCULAR ADAPTATIONS AND PAIN MANAGEMENT

BFR is characterized by the application of pneumatic cuffs to the proximal part of a limb to decrease arterial and block venous blood flow [7]. Venous blood pooling is thought to increase metabolic stress due to a change in energy metabolism in favor of anaerobic processes and accumulating metabolites [8, 9], which accelerates muscle fatigue development [10]. In this regard, invasive catheter studies demonstrated that low-load resistance exercise under venous occlusion causes hypoxemia in the exercising limb [11]. Further occurring mechanisms (e.g., increased type II muscle fiber recruitment and cell swelling) are assumed to trigger signal cascades which increase protein synthesis and thus, induce muscle hypertrophy [8, 9]. In addition, BFR is able to reduce pain due to provoking hypoalgetic effects [12]. Considering the current evidence, BFR-induced hypoalgesia is probably caused by a conditioned pain modulation [13] (i.e., diffuse noxious inhibitory control-like effect [14] or "pain inhibits pain" [15]) where a reduction in pain perception is evoked by another heterotopically applied noxious stimulus [16]. Another possible mechanism is the activation of the endogenous opioid and endocannabinoid systems due to stimulation of group III and IV afferents leading to the production of specific neurotransmitters, which modulate the sensitivity of nociceptors [17, 18].

BFR IN CLINICAL PRACTICE IN PHASES OF IMMOBILIZATION OR SEVERELY RESTRICTED MOBILITY

Preoperative treatment of degenerative diseases and/or elective surgery

Considering the main benefits of BFR training, inducing significant adaptations in the muscular system with the associated ability to reduce pain, its application in the medical field is of particular interest. Joint arthrosis is one of the major diseases affecting the skeletal system, leading to severe reductions in mobility as well as in skeletal muscle mass and strength [19, 20]. Total joint replacement (e.g., total knee arthroplasty, TKA) is often the last option to maintain or restore mobility. However, the surgery itself and early postoperative immobilization usually causes further progression of muscular atrophy and strength loss [21]. Therefore, an improvement in patients' functional and morphological resources before elective surgeries such as TKA is a strong predictor for a better postoperative outcome [22, 23]. While previous attempts about prehabilitation (i.e., exercise programs prior to a surgery) showed too small and/ or only short-term effects in improving postoperative function and reducing pain after joint replacement surgery [24], BFR could provide a decisive new alternative to create a favorable functional and morphological environment before surgery. Prehabilitative treatment with BFR training has already been shown to have a major impact on pre- and postoperative muscle

mass, strength and function in patients receiving elective TKA [25] or abdominal surgery [26].

Postoperative treatment or conservative rehabilitation

In the early postoperative period, especially during complete immobilization, BFR can be used passively (i.e., without additional exercise) to counteract the injury/ surgery-induced loss of muscle mass [27], strength [28, 29], and to reduce local pain [30]. If possible, resistance exercises with very low loads can be performed during phases of limited mobility. It has been shown that low-load BFR training induces similar increases in muscle mass to high-load [6] and low-load training performed until exhaustion [31]. In this regard, especially low-load BFR training might be a convenient option as high mechanical stress of high-load training is avoided and cumulative low mechanical stress of low-load training until exhaustion is reduced (i.e., due to lower total work) [32]. Furthermore, Korakakis et al. have shown that BFR combined with low load knee extension exercise not only reduced anterior knee pain but also allowed the patients tolerate higher mechanical loads in subsequent therapy sessions [14, 33] which, in turn, favors gains in muscle strength. Therefore, Bielitzki et al. proposed that an early integration of BFR potentially accelerates the recovery process compared to traditional care [32].

TAB. 1 Overview of possible contraindications of BFR training (according to Brandner et al. [44])

CONTRAINDICATION	EXPLANATION
Cardiovascular diseases	Coronary heart disease, unstable hypertension, peripheral vascular disease, venous thromboembolism, hypercoagulable state, cardiopulmonary conditions, atherosclerotic vessels, myocardial ischemia, left ventricular dysfunction, varicose veins, Marfan syndrome
Musculoskeletal injuries	Muscle trauma or crush injuries, postsurgical excess swelling, open fractures, open soft tissue injuries, skin graft
Individual characteristics and lifestyle	Age, smoking, weight, (especially overweight), pregnancy, diabetes mellitus, dyslipidemia, dehydration
Family and medication history	Blood clotting disorders, sickle cell anemia, atrial fibrillation, heart defects, cancer, medications to increase blood clotting
Overtraining	Elevated creatine kinase and myoglobin levels

Safety information

Generally, there is no increased risk of adverse health events when performing BFR training [34]. Apart from side effects of traditional exercise/ training (e.g., muscle damage/ soreness), the most common adverse events are tingling sensations in distal extremities (71.2 %), hematomas (4.8 – 13.1 %), and numbness (1.3 – 26.9 %). In few cases, serious side effects such as rhabdomyolysis (0.01 – 1.9 %) or venous thrombus formation (0.06 %) may occur [35, 36]. However, BFR exercise may cause an increased response of the metabolic and cardiovascular systems (lactic acidosis, venous hypertension) [37, 38]. To minimize the risk of adverse health events, patients should be screened for possible contraindications (Table 1). However, if used appropriately, BFR can also be applied in critically ill patients (e.g., patients with chronic kidney [39] or cardiovascular disease [40]).

TAB. 2 Recommendations for the application of BFR during immobilization and severely limited mobility (modified according to Patterson et al. [34]).

	NO ADDITIONAL EXERCISE	AEROBIC EXERCISE	RESISTANCE EXERCISE
Cuff width	10 – 12 cm for lower extremities		
Frequency	1 – 2 times a day		
Load	-	< 50 % $\dot{V}O_{2max}$ or HRR	10 – 20 % 1RM [41, 45]
Cuff pressure	≥ 80% AOP	80% AOP* [18]	80 % AOP* [17, 41, 45]
Restriction time	5 min intervals	5 – 20 min	5 – 10 min
Sets	3 – 5	-	4 (30-15-15-15 repetitions) or 2 – 4 to failure
Execution speed	-	-	1 – 2 s concentric 1 – 2 s eccentric
Restriction type	Continuous	Intermittent or continuous	Intermittent# or continuous

1RM, one repetition maximum; AOP, arterial occlusion pressure; HRR, heart rate reserve; $\dot{V}O_{2max}$, maximal oxygen uptake
recommendations refer to *hypoalgetic effects, #safety considerations

RECOMMENDATIONS FOR APPLICATION DURING STRONGLY REDUCED LOAD CAPACITY

Considering the current recommendations, Table 2 provides guidance for the proper application of BFR training during immobilization and strongly limited mobility with very low-load tolerance with the goal of optimizing training efficacy and patient safety [34]. Especially in these phases, it seems necessary to set an adequate high level of cuff pressure in order to induce beneficial effects. For example, Mouser et al. have shown that only high pressures combined with very low-load resistance training induced beneficial vascular adaptations similar to high-load resistance training [41]. Furthermore, the studies by Hughes et al. demonstrated that high pressures are more likely to induce hypoalgetic effects than low pressures combined with low-load resistance and aerobic exercise [17, 18].

CONCLUSION

Considering the current evidence on muscle mass and strength in clinical populations [42, 43], BFR provides a promising method for patients especially during immobility or periods of strongly reduced mobility with very low mechanical resilience. While a preoperative treatment can create a protective effect on the surgical limb to reduce post-surgical strength loss and muscle atrophy [3], post-injured / post-surgical therapy can be supported by the application of BFR, either passive or combined with very low-load exercises, to regain pre-traumatic / pre-surgical strength level faster compared without using BFR [32].

The literature can be found at the Article on www.sportaerztezeitung.com

ROBERT BIELITZKI

Department of Sport Science, Otto-von-Guericke University Magdeburg

TOM BEHRENDT

Department of Sport Science, Otto-von-Guericke University Magdeburg

PROF. LUTZ SCHEGA

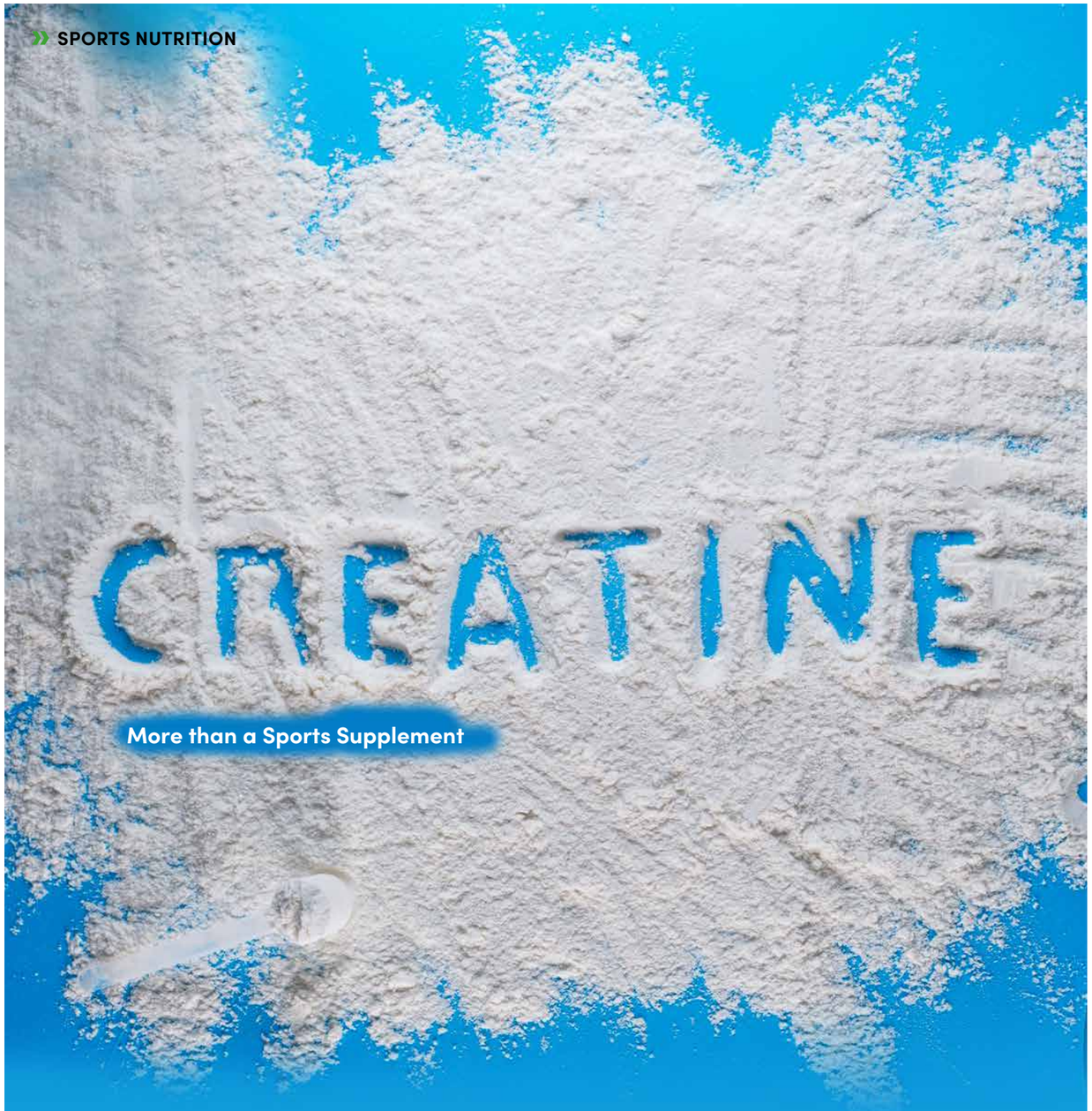
Department of Sport Science, Otto-von-Guericke University Magdeburg

PROF. MICHAEL BEHRINGER, MD

Department of Sport Science, Goethe University Frankfurt

ALEXANDER FRANZ, MD

Department of Orthopedics and Trauma Surgery, University Hospital Bonn



More than a Sports Supplement

PROF. RICHARD B. KREIDER, PHD /
EXERCISE & SPORT NUTRITION LAB, DEPARTMENT OF KINESIOLOGY AND SPORT MANAGEMENT, TEXAS A&M UNIVERSITY, USA

Since the early 1990s, creatine supplementation (as creatine monohydrate) has been reported to improve high-intensity exercise performance and training [1, 2]. For this reason, creatine supplementation has been a nutritional strategy to enhance performance and training adaptations among individuals initiating training and athletes [3]. However, we now know there is much more to creatine supplementation than exercise and sport performance enhancement.

Creatine supplementation increases cellular energy availability and supports general health, fitness, and well-being throughout the lifespan [4 – 6]. Research over the last 30 years has shown that creatine supplementation has a number of potential health benefits and uses in clinical populations [5]. In fact, as the public has become aware of the potential health benefits of creatine, worldwide sales of products containing creatine have more than doubled [7]. The following describes the role of creatine supplementation on health as we age. For more information on each of these topics, see CreatineForHealth.com.

1. PROMOTE REPRODUCTIVE HEALTH

Creatine plays a key role in metabolism, including in reproductive health, pregnancy and newborn health [8]. In this regard, there is evidence that creatine availability affects sperm quality, motility, and viability [9]. Consequently, creatine supplementation has been suggested for men with low sperm count as well as added to medium during intrauterine insemination in order to enhance sperm motility and fertilization success [5]. Moreover, there is a greater maternal need for dietary creatine during fetal development [8, 10]. Low creatine availability during pregnancy has been associated with low birth weight and pre-term birth [11, 12]. Increasing the dietary availability of creatine during the third trimester has been reported to reduce the risk and complications of fetal asphyxia during childbirth (i.e., lack of oxygen) and brain trauma in animals [8, 10 – 12]. Creatine has also been suggested as a means to enhance the ability of the mother to withstand and recover from contractions during natural childbirth as well as promote women's health throughout the lifespan [10]. Although more research is needed, these findings suggest creatine plays an important role in reproductive health for both men and women.

2. PROMOTE MATURATION IN CHILDREN AND ADOLESCENTS

Some children are born with creatine synthesis enzyme deficiencies and can't synthesize enough creatine to maintain normal brain and muscle levels. This typically presents with delayed motor and cognitive maturation. Creatine supplementation in children with some forms of creatine synthesis deficiencies has been reported to have better neuromuscular and cognitive development [13 – 15]. Additionally, low dietary intake of creatine has been correlated with a shorter stature, lower body weight, and higher percentage of body fat in children and adolescents aged 2 – 19 years [16, 17]. These findings suggest that dietary availability of creatine is important for normal growth and maturation. Since dietary creatine is primarily obtained from red meat, chicken, pork, and fish like salmon (e.g., 0.4 – 0.8 grams per serving), parents should ensure their children consume sufficient amounts of these foods in their diet and supplement their diet with pure creatine monohydrate if dietary intake is inadequate (e.g., 1 teaspoon is about 5 grams).

3. ENHANCE FITNESS IN ACTIVE ADULTS

While there are a number of studies indicating that creatine supplementation (e.g., 0.3 g/kg/d for 5 – 7 days and 0.03 g/kg/d thereafter) increases strength, muscle mass, and performance in athletes engaged in strength and conditioning programs [18], it can also help individuals starting exercise programs observe greater success, recreational athletes improve performance and training adaptations, and active individuals maintain fitness and muscle mass [5]. In fact, while creatine is often thought to be a supplement for athletes, the largest consumer market for sports nutrition supplements are middle-aged adults trying to maintain strength, muscle mass, and fitness as they age. Consequently, creatine is commonly used by active adults to enhance fitness levels and performance in recreational sport activities [5, 10, 19].

4. MAINTAIN HEALTH, FITNESS, AND COGNITIVE FUNCTION AS WE AGE

One of the greatest potential uses of creatine is as a nutritional countermeasure to slow the negative effects of aging [19]. As we age, we typically lose strength and muscle mass while gaining body fat (i.e., adult onset of obesity). We also experience cognitive decline and memory loss. Dietary intake of creatine and/or the ability to digest foods containing creatine generally declines as we age leading to lower muscle and brain creatine content. Creatine supplementation in older populations has been found to increase strength and muscle mass as well as help maintain bone mass and reduce risk to falls [19, 20]. There is also evidence that creatine supplementation increases creatine content in the brain and thereby enhances cognitive function and memory in older individuals [21, 22]. Additionally, creatine supplementation while maintaining an energy-restricted diet may be an effective way to preserve muscle and help manage adult-onset obesity. Consequently, daily supplementation of pure creatine monohydrate (e.g., 3 – 5 g/d) may be more important as we age to maintain functional capacity, cognitive function, and memory.

5. HELP MANAGE CHRONIC DISEASE AND REDUCE RISK TO INJURY

In addition to general health benefits, there is also evidence that a lack of availability of creatine impairs cellular function and can complicate management of a number of diseases [4, 6]. For example, creatine has been reported to improve glucose homeostasis [23] and have anti-inflammatory [4 – 6, 10, 21, 24], antioxidant [5, 24, 25] and immunomodulating [26] effects. There is also evidence that creatine serves as an important energy source during ischemic

PROF. RICHARD B. KREIDER, PHD, FACSM, FASEP, FISSN, FACN, FNAK

is Professor and Director, Exercise & Sport Nutrition Lab, Department of Kinesiology & Sport Management, College of Education & Human Development, Texas A&M University, USA.

conditions (e.g., ischemic heart disease, heart attack, stroke) [5, 24], brain and spinal cord injury/trauma [3, 5, 21, 27, 28], T-cell antitumor immunity [29, 30], and the pathology of some mitochondrial dysfunction conditions [6]. For this reason, creatine supplementation has been studied as an adjunctive therapeutic strategy in various clinical populations. For example, creatine supplementation has been reported to help individuals with type 2 diabetes mellitus better manage blood glucose levels when combined with resistance-training [23]. Moreover, some therapeutic benefits have been reported related to vascular disease [25], heart disease [24], and slowing the progression of some cancerous tumors [29, 30]. Feeding animals creatine has been reported to reduce the size and severity of heart, brain, and spinal cord damage in response to experimentally-induced ischemic conditions, traumatic brain injury, and spinal cord injury [3, 5, 6, 21, 24, 27, 28]. In fact, the International Society of Sports Nutrition recommends that individuals at risk to head and/or spinal cord injury consider taking creatine for neuroprotection [1]. Finally, there is evidence that creatine supplementation reduces the incidence and severity of musculoskeletal injuries in athletes engaged in intense training [1, 31, 32] and can promote recovery from musculoskeletal injury [33]. Therefore, creatine supplementation may play an adjunctive role in the management of several chronic diseases, reduce risk to injury, and/or promote recovery and rehabilitation.

6. THERAPEUTIC NUTRIENT FOR CHRONIC VIRAL FATIGUE AND LONG-COVID?

People often experience chronic fatigue and lethargy after exposure to viral infections. For example, millions of people who have had COVID19 complain of symptoms of fatigue, mental or brain fog, lack of energy and endurance, and lethargy for months or more after recovering from COVID (i.e., long-COVID). People experiencing these symptoms often reduce physical activity which can complicate recovery, promote obesity, and increase risk and/or progression of chronic disease. Since creatine can increase brain bioenergetics and has been shown to provide some therapeutic benefit for patients with chronic fatigue-related syndromes such as post-viral fatigue syndrome (PFS) or myalgic encephalomyelitis (ME), it is possible that creatine supplementation can help people with long-COVID increase physical activity and cognitive function [6, 34]. Future research should assess this potential therapeutic role of creatine supplementation.

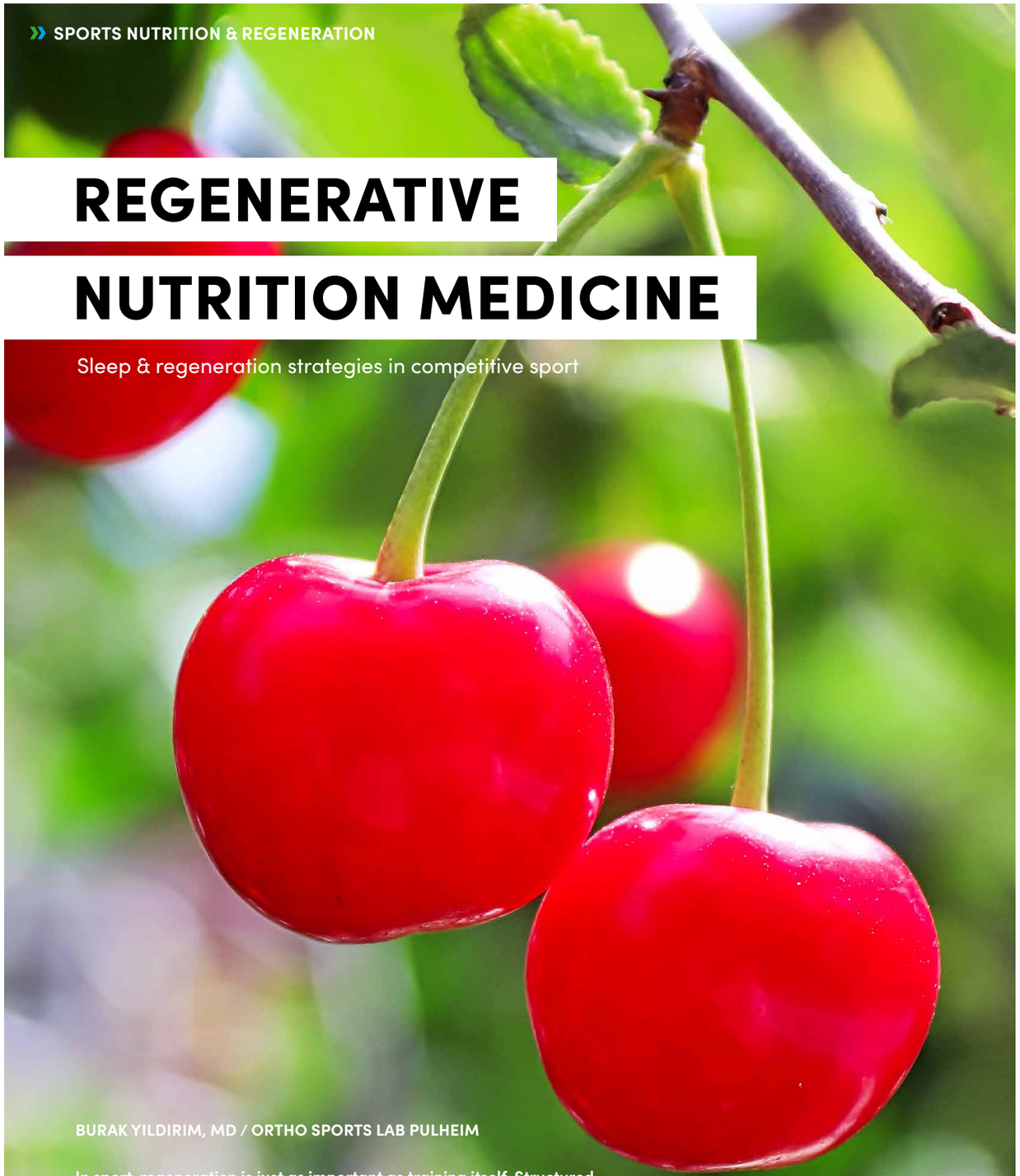
SUMMARY

The benefits of creatine supplementation go well-beyond enhancing high-intensity exercise performance and training adaptations for athletes. Research has clearly shown a number of health and/or potential therapeutic benefits as we age and in clinical populations. Although additional research is needed to further explore the health and potential therapeutic benefits of creatine supplementation, it is recommended that people consume at least 2 – 3 grams (i.e., 0.03 g/kg/d) of creatine per day from food (e.g., red meat, chicken, pork, salmon, tuna) and/or dietary supplementation of pure creatine monohydrate to support general health [5]. For those interested in optimizing performance, training, and recovery, we recommend loading with a pure source of creatine monohydrate for 5 – 7 days (0.3 g/kg/d) and then ingesting maintenance doses (0.03 g/kg/d). For those interested in taking creatine to help manage chronic disease, we suggest you share some of the peer-reviewed articles and presentations available at CreatineForHealth.com with your healthcare provider and discuss whether creatine supplementation may be something to consider to help you manage your health condition.

The literature can be found at the Article on www.sportaerztezeitung.com

REGENERATIVE NUTRITION MEDICINE

Sleep & regeneration strategies in competitive sport



BURAK YILDIRIM, MD / ORTHO SPORTS LAB PULHEIM

In sport, regeneration is just as important as training itself. Structured and regular regeneration helps to cope with exercise better and to exercise again rapidly. During the regeneration period, which depends on the duration and intensity of the exercise, the organism is given the opportunity to adapt to the exercise stimuli. Thus, regenerative measures serve the physiological balance and the provision of functions that resupply the body.

In modern society, physical and mental regeneration plays an increasingly important role in restoring overall performance. Relaxation, serenity, well-being and contentment are closely linked to work-life balance and mindfulness. Regeneration is thus an important tool for improving self-regulation, whether to relieve acute/chronic states of ten-sion or to manage stress with ritualised settings. By definition, regeneration (from Latin: re – back, generare – to produce, generate) means renewed revival and revitalisation of the organism. It is therefore of great importance in medicine, sport and society in terms of the functional and morphological restoration of physical resources.

"TRINITY OF HEALTH" AND FURTHER MEASURES

In addition to the "trinity of health" (E. Rambourg), consisting of sleep, nutrition and exercise, other regeneration measures available include autogenic training, yoga, meditative practices, physical & manual treatments as well as functional relaxation (such as fascia or biofeedback training). Balanced sleep has now become an elusive luxury. In times of social media and the so-called meritocracy, "career" people boast about how little sleep they need because they lead supposedly exciting, successful and demanding lives and perform multiple tasks at the same time. Sleeping is said to be a waste of time and a waste of life because an 8-hour night's rest would mean missing 1/3 of your life. Or have you ever heard someone bragging about how well they sleep and how it makes them feel energetic and full of energy? Yet, according to studies, many people suffer from sleep disorders and the associated side effects. The book "Why we sleep" by the US neuroscientist and sleep researcher Matthew Walker impressively shows, among other things, the importance of sleep in preventing Alzheimer's, cancer and heart attacks. Sleep may not yet be sexy enough, but this seems to be changing. Customers are willing to pay to recharge their batteries on stressful work days. Whether at Dreamery by Casper, a New York Nap Bar, where a 45-minute nap costs $25, or in France at the so-called ZZZen Trucks, where mobile opportunities for relaxation are offered.

SLEEP DISORDERS AND THE IMPORTANCE OF MELATONIN

When dealing with the topic of sleep disorders, stress, physical or mental illnesses, medication, alcohol and caffeine consumption, hormonal metabolic changes, shift work, but also, especially in sports, travel and late kick-off times play a decisive role. When it comes to nutrition to improve sleep, the media regularly mention valerian, vitamins B1 and B6 and, most recently, melatonin, the natural sleep hormone. Melatonin controls the day-night rhythm and is synthesised from serotonin, which is obtained from the essential amino acid tryptophan. In addition to promoting sleepiness and facilitating falling asleep, melatonin acts as a radical scavenger in mitochondria ("powerhouse of the cell") and promotes the expression of antioxidant enzymes. The queen among foods is the Montmorency tart cherry from Michigan/USA. With its high nutrient (secondary plant substances) and melatonin content, it is an antioxidant, promotes sleep and also has anti-inflammatory and uric acid-lowering effects.

Elevated uric acid levels play an essential role in sports medicine regarding acute and chronic diseases and injuries. Elevated plasma and tissue levels of uric acid are found in about 30 % of men and 3 % of women [1]. In men, this is independent of age. Women initially benefit from the uricosuric effect of oestrogens, which leads to lower uric acid levels. After the menopause, however, the levels rise due to changes in the hormone balance. If the uric acid in the blood rises above 7 mg/dL, e.g. through physical work or sport, it can precipitate in crystalline form and be deposited in the efferent urinary tract, in the bloodstream and in bradytrophic tissues such as tendons and cartilage [2, 3]. For example, the connection between tendinopathies and hyperuricemia has been documented several times in the literature, and is basically old hat [4]. Dodds et al. from New Zealand compared the serum uric acid levels of 30 patients with Achilles tendon rupture with those of 30 healthy controls matched for age and sex. Serum

BURAK YILDIRIM, MD

is a specialist in orthopaedics and trauma surgery, sports medicine, team doctor (VBG). After working at the Mediapark Klinik Cologne and Sportsclinic Cologne, he founded ORTHO SPORTS LAB in Pulheim. From 2008 to 2011, Dr Yildirim was the team doctor for the U15 – U19 national teams of the German Football Association (DFB), and since 2013 he has been the team doctor for the Bundesliga team Bayer 04 Leverkusen.

uric acid levels were significantly higher in patients with a ruptured Achilles tendon than in controls. This finding was not dependent on gender or ethnicity [5]. Uric acid deposits between the tendon cells decrease stiffness and reduce the elasticity of the tendon tissue. It is therefore assumed that this finding may be related to an adverse effect on tendon nutrition.

CHRONIC INFLAMMATIONS

Uric acid deposits in the body can be impressively displayed and detected by special CT examinations (dual-energy CT). And these chronic inflammations, some of which are very stubborn, present us with major challenges in our daily practice, especially when conventional therapies do not show sufficient effect. From a preventive and therapeutic point of view, the Montmorency tart cherry provides us with a natural and potent tool for dietary management to lower uric acid and thus have an anti-inflammatory effect. The tart cherry juice inhibits the enzyme xanthine oxidase, which is necessary for the formation of uric acid [6]. Another study showed that drinking 30 – 60 mL Montmorency tart cherry juice concentrate increased uric acid excretion in volunteers by 250 %, resulting in a 36 % decrease in blood uric acid concentration [7]. Eating cherries can reduce the risk of a gout attack by 35 %, as a cherry juice concentrate by 45 %, and in combination with allopurinol even by up to 75 % in a total of 600 subjects [8].

Xanthine oxidase inhibitors are usually administered to prevent the "salting out" (crystallisation) of uric acid (urate). Active substances on the market are allopurinol and febuxostat. They have a uricostatic effect, i.e. they inhibit the synthesis of uric acid. However, uric acid crystals that have already been deposited cannot be removed from the tissues with these active substances. This can be achieved, for example, by eating grapes or so-called uricosurics, which can help dissolve urate crystals and make them easier to excrete.

FIG. 1 MRI (left initial, right follow-up after two weeks)

PRACTICAL EXAMPLE

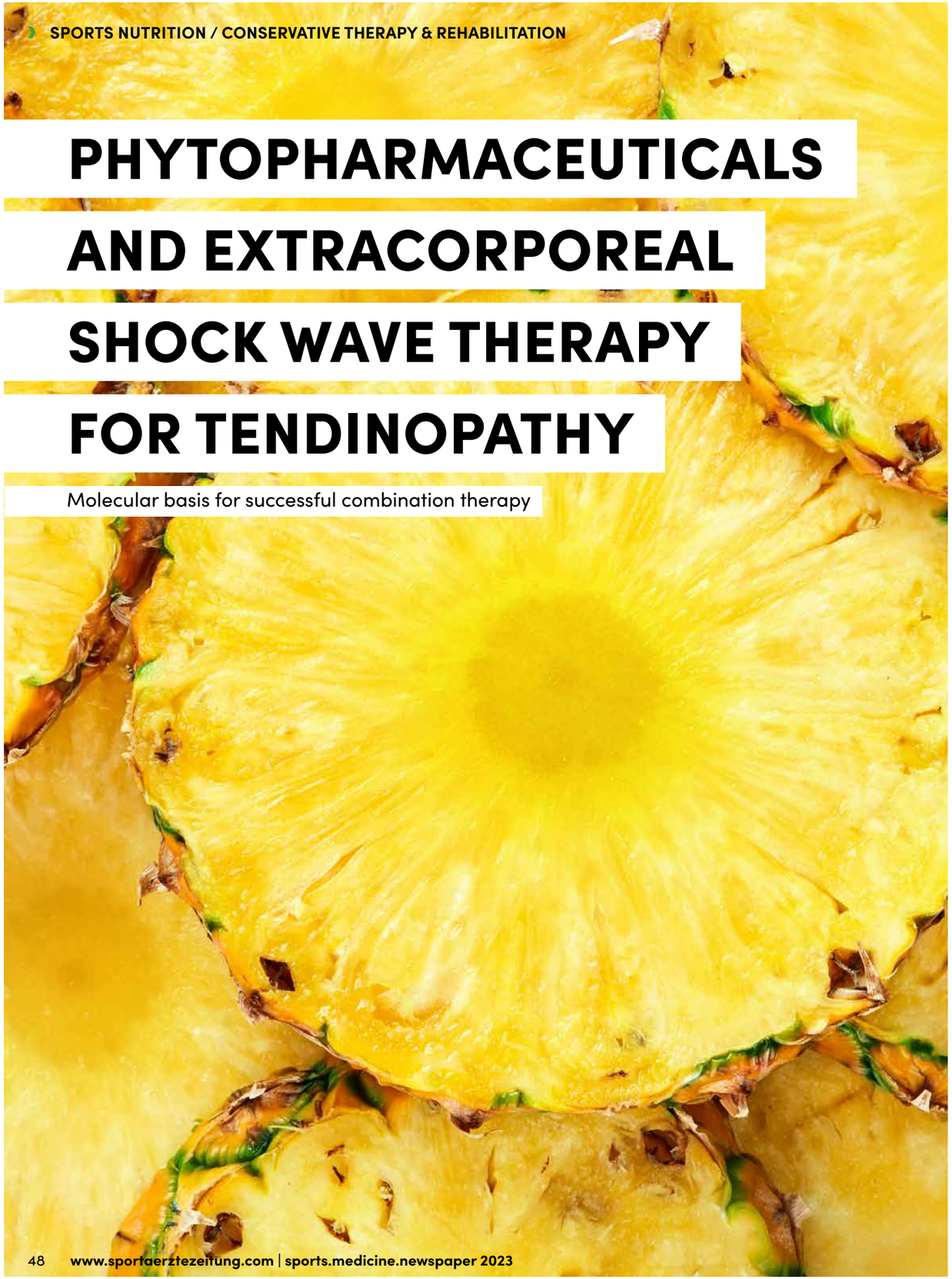
The following practical example shows how significant strategic use can be for the short-term treatment of uric acid:

The MRI image on the left shows a recalcitrant tendinosis with partial rupture of the proximal patellar tendon in a 19-year-old professional football player, which could not be alleviated by physiotherapy, shockwave or injection treatments. Surgery was now recommended and he presented at our practice for further assessment. After the use of 100 mg benzbromarone (uricosuric), the symptoms and inflammation were reduced in the MRI after only 14 days (Fig. 1 right MRI follow-up after two weeks).

CONCLUSION

Montmorency tart cherry lowers uric acid levels naturally, effectively and without any known side effects (primary prevention). The Montmorency tart cherry concentrate can be easily integrated into a performance-oriented diet and is perfect as post-workout nutrition (shakes / capsules). It has the extraordinary potential to support regeneration after sports. It has an antioxidant effect, inhibits stress-induced inflammation, and improves sleep quality with its high melatonin content. "Mens sana in corpore sano", a Latin phrase from the Roman poet Juvenal, means "a healthy mind in a healthy body". The triad of sleep, nutrition and exercise provides us with the natural foundations for this.

The literature can be found at the Article on www.sportaerztezeitung.com



PHYTOPHARMACEUTICALS AND EXTRACORPOREAL SHOCK WAVE THERAPY FOR TENDINOPATHY

Molecular basis for successful combination therapy

Photo: © istockphoto.com / Pineapple Studio

ANNA-LENA MÜLLER[1], ARANKA BROCKMÜLLER[1], DR. CHRISTOPH SCHMITZ M.D.[2] AND DR. MEHDI SHAKIBAEI[1]

[1]DEPARTMENT OF ANATOMY I, LMU MUNICH
[2]DEPARTMENT OF ANATOMY II, LMU MUNICH

In simplified terms, the initial phase of tendinopathy treatment focusing on reducing pain and inflammation must be followed by a second phase to promote effective tendon regeneration. It is now well-known that extracorporeal shock wave therapy (ESWT), corticosteroids, non-steroidal anti-inflammatory drugs (NSAIDs) and certain phytopharmaceuticals (in this specific case, bromelain, curcumin and boswellic acid) are safe and effective in the initial phase (the list is representative but not exhaustive).

Far less well-known, on the other hand, are the (positive and negative) effects of these treatments and drugs in the second phase, which is particularly crucial for combination therapy.

INFLAMMATORY PROCESSES IN TENDON TISSUE

Tendinopathies are tendon problems that arise due to degeneration and secondary inflammation and are steadily becoming more common, particularly in sports medicine. To date, up to 50 % of the diagnoses requiring treatment in sports medicine involve tendinopathy [1, 2]. This is due to both continuous overuse and mechanical stress on the tissue in sports activities and to inappropriate loading in daily life; however, rare adverse drug reactions are also known to be triggers. Moreover, lifestyle factors such as poor diet and lack of exercise may also be substantially involved in inflammatory processes in tendon tissue [3 – 5]. These usually manifest as pain and restricted movement and considerably reduce the quality of life of the affected subjects [6, 7]. To counteract these circumstances as rapidly as possible, NSAIDs and corticosteroids are currently still widely used internationally to inhibit central pro-inflammatory mediators and thereby suppress inflammatory responses and alleviate both pain and swelling [8, 9]. This involves the targeting of molecules such as MAP (mitogen-activated protein) kinases and NF-κB (nuclear factor kappa B), which play a major role in inflammatory processes and act as switches that can be turned on or off, either inducing or stopping inflammatory cascades. Consequently, this also influences the expression of other molecules involved in signaling pathways such as COX-2 (cyclooxygenase-2) and MMPs (matrix metalloproteinases) [9 – 13].

However, although these drugs provide temporary relief, they are also known to have many undesirable effects. In fact, these drugs may not only cause long term damage to other organ systems [14 – 16] but can actually block tendon regeneration, which is the opposite of what is desired when treating tendinopathies [17 – 21]. Studies have shown that particularly corticosteroids (e.g., dexamethasone) und NSAIDs (e.g., celecoxib), still the standard treatment for tendinopathy in many countries, downregulate not only inflammatory molecules but also the gene expression of the transcription factor scleraxis. The latter can be considered as a marker gene for the vitality of tenocytes (i.e., the characteristic cells of the tendons and ligaments responsible for the development and remodeling of the extracellular matrix (ECM)), as it induces tenocytes not only to form new ECM but also to synthesize collagen I and tendon-specific proteoglycans, the primary components of the ECM [13, 21 – 23]. This explains why a drug-induced decrease in the gene expression of scleraxis also contributes to a marked reduction in the regenerative capacity of tendon tissue, which is hugely important particularly for athletes. At the same time, the decrease in collagen formation in combination with pain-relieving drugs also increases the risk of tendon tears, as pain is suppressed but with a concomitant loss of tissue flexibility and function [24, 25]. This highlights the need for alternative treatment methods that can be used to support regeneration, i.e., the formation of tendon tissue. Various studies have demonstrated precisely these properties in various phytopharmaceuticals such as bromelain, curcumin and boswellic acid. Their modulating effect allows these phytopharmaceuticals to interrupt inflammatory cascades and simultaneously stimulate anabolic processes in tendon cells, e.g., by increasing the expression of scleraxis und matrix-specific proteins (Tables 1 + 2) [2, 26 – 42].

EFFECTS OF PHYTOPHARMACEUTICALS

Bromelain, the main ingredient in Wobenzym®, is an enzyme extracted from pineapples that has long been used in traditional medicine to alleviate pain and swelling [43 – 46]. This effect is primarily due to the decrease in stress markers, such as the MDA (malondialdehyde) level, in tenocytes and the resulting interruption of inflammatory processes [46]. In terms of the regenerative effect of bromelain, it has also been shown that the enzyme stimulates particularly tenocyte formation, i.e., new tendon tissue develops, thus supporting the healing of injuries [2, 32]. It has not yet been addressed in the literature whether bromelain also acts directly on the gene expression of scleraxis.

Similar effects in tendon tissue have also been achieved with the use of curcumin. As one of the many components of curcumin root, curcumin has gained

TABLE 1 **Effect of boswellic acid, bromelain and curcumin components on tendon tissue.**

PLANT SUBSTANCE	ORIGIN	TYPE OF STUDY	YEAR	FINDING	ADMINISTRATION	REFERENCE
BOSWELLIC ACID	*Boswellia serrata*	*Clinical,* patients with Achilles tendinitis or epicondylitis	2014	Administration of boswellic acid as Casperome® increased the effectiveness of physical therapy, led to pain reduction on the visual analogue scale, functional improvement and less need for NSAIDs.	250 mg Casperome®/ 15 and 30 days	[27, 63]
		Clinical, rugby players with inflammation of the knee	2016	Administration of boswellic acid as Casperome® increased the effectiveness of the standard treatment, reduced pain and inflammatory parameters.	500 mg Casperome®/ 5 days, then 250 mg / 23 days	[28]
BROMELAIN	*Ananas comosus*	*In vivo,* Sprague-Dawley rats with Achilles tendon injury	2010	Administration of pineapple extract stimulated tenoblast proliferation and thus tendon healing.	30 mg/kg pineapple extract/ 14 days	[46]
		In vivo, Sprague-Dawley rats with Achilles tendon injury	2011	Bromelain shifted the prostacyclin-thromboxane ratio towards prostacyclin and increased the tenocyte population.	7 mg/kg bromelain/ 14 days	[2, 32]
		Clinical, patients with Achilles tendinitis	2012	Administration of Tenosan® (including bromelain) increased the effectiveness of extracorporeal shock wave therapy and improved the clinical functional outcome.	2 sachets daily incl. 50 mg bromelain/ 60 days	[33]
		Clinical, patients with rotator cuff tendinopathy	2012	Administration of Tenosan® (including bromelain) reduced postoperative pain and improved repair integrity.	2 sachets daily incl. 50 mg bromelain/ 3 months	[31]
CURCUMIN COMPONENTS	*Curcuma longa*	*In vivo,* rats with diabetic metabolic state	1998	Curcumin reduced oxidative stress by impeding lipid peroxidation and prevented the cross-linking of collagen with high glycogen content.	200 mg/kg curcumin/ 8 weeks	[36]
		In vivo, rats with diabetic metabolic state	2007	Tetrahydrocurcumin reduced the cross-linking of collagen with high glycogen content.	80 mg/kg tetrahydrourcumin/ 45 days	[41]
		In vitro, human tenocytes	2011	Curcumin prevented both inflammation and apoptosis and demonstrated potential for the treatment of tendinitis.	5 µM curcumin	[35]
		In vivo, Sprague-Dawley rats with patellar tendon injury	2015	Curcumin improved the quality of healing in tendon tears by promoting the deposition of well-organized collagen fibres.	100 mg/kg curcumin/ 14 days	[37]
		In vivo, Sprague-Dawley rats with Achilles tendon injury	2016	Curcumin inhibited inflammation and lowered the level of postoperative peritendinous adhesions.	1 injection incl. 0.44 mg curcumin/kg	[38]
		In vivo, Wistar albino rats with Achilles tendon injury	2018	Curcumin promoted the formation of collagen I and collagen III, which had a positive effect on postoperative healing.	200 mg/kg curcumin/ 28 days	[39]
		In vivo, rats with tendinopathy	2019	Curcumin inhibited inflammation, prevented tendon calcification and supported tendon regeneration by promoting tendon stem cells.	3 µg curcumin every 3 days / 4 weeks	[40]
		In vivo, Sprague-Dawley rats with rotator cuff injury	2021	Curcumin exerted an antioxidant and anti-inflammatory effect, protected both tendon stem cells and tendon matrix and improved tendon-bone healing.	1 injection mit 50 µl Cur&Mg-QCS/PF hydrogel	[42]
		In vitro, canine tenocytes	2022	Calebin A inhibited inflammation and prevented inflammation-induced down-regulation of tenomodulin and collagen I, thus demonstrating potential for both prevention and treatment of tendinitis.	1–10 µM Calebin A	[26]

particular significance in recent years as a herbal anti-inflammatory agent [47–50]. This effect is based on the capacity of curcumin to target various signaling pathways involved in inflammatory processes. Modulation of the inflammatory marker NF-κB can be considered as one of the primary targets of curcumin. With the inhibition of NF-κB, all pro-inflammatory cascades and end molecules such as COX-2 and MMPs regulated by NF-κB are also turned off, resulting in the inhibition of inflammation at various molecular levels [35, 42]. It is, however, the marked anabolic effect of curcumin that is crucial for the regeneration process in tendinopathy [35–40, 42]. Specifically, it has been shown that curcumin strongly upregulates the expression of collagen, thereby boosting collagen synthesis [35, 39]. It has also been demonstrated that curcumin can prevent the calcification that commonly occurs after a tendon injury with chronic inflammation by downregulating osteogenesis, i.e., the formation of bone, locally at the injury site and simultaneously stimulating tenogenesis, i.e., the formation of new tendon cells [40]. Apart from curcumin, Calebin A (a further bioactive component of the curcumin root) is also gaining increasing prominence due to its anti-inflammatory mode of action [51, 52]. In a recently conducted study we showed that Calebin A is able not only to inhibit inflammatory cascades, such as the NF-κB signaling pathway and its pro-inflammatory end products, but also to upregulate scleraxis in tendon cells, which is highly relevant particularly for tendon tissue regeneration [26]. The multi-modulatory effect of Calebin A becomes even more clear if one considers that a functional connection between NF-κB and scleraxis has also been demonstrated [26]. The anti-inflammatory and regeneration-promoting effect of Calebin A illustrates its potential at different levels in the treatment of tendinopathy.

Boswellic acid, an extract from the gum resin of the Boswellia tree, has also been successfully used in many studies as an anti-inflammatory and pain-relieving active substance for musculoskeletal symptoms [27, 53–55]. Its particular potential lies in inhibiting pro-inflammatory processes and messenger substances that play a crucial role in the pathogenesis of tendinopathy. The crucial factor here is especially that the molecules that contribute to matrix degradation (MMPs, COX-2) are also turned off [27, 28, 56]. This prevents the further degradation of particularly collagen and other important components of the ECM, thus interrupting the loss of tendon cells at the pathology site and maintaining their vitality. Furthermore, the formation of ECM is necessary to ensure the formation of new tenocytes, as the ECM is essential for their integrity at many levels [35, 57–59]. Rapid pain relief and less restricted movement have also been reported in a clinical study involving the administration of a combination of boswellic acid and curcumin extracts to patients with tendon symptoms [29, 30, 60]. Moreover, this phytopharmaceutical combination (curcumin and boswellic acid) has been shown to be more effective compared to celecoxib in the treatment of patients with osteoarthritis, which further supports the findings regarding the modulatory and anabolic properties of phytopharmaceuticals at the molecular level [61]. As in case of bromelain it has not yet been addressed in the literature whether boswellic acid also acts directly on the gene expression of scleraxis.

COMBINATION OF ESWT & PHYTOPHARMACEUTICALS

The effectiveness of ESWT in the treatment of tendinopathy has also been demonstrated at the highest level of evidence in a variety of studies (both clinical and in basic research) conducted by members of our group (e.g., [62, 63]).

TABLE 2 Combined effect of boswellic acid, bromelain and curcumin components on tendon tissue.

PLANT SUBSTANCES	TYPE OF STUDY	YEAR	FINDING	ADMINISTRATION	REFERENCE
Boswellic acid + *curcuma longa* extract (as Tendisulfur®)	*Clinical,* patients with supraspinatus tendon injury	2015	The combination of Boswellic acid and *curcuma longa* extract as Tendisulfur® reduced pain post arthroscopy compared to the placebo treatment.	2 sachets daily Tendisulfur®/ 15 days, then 1 sachet daily/45 days	[29]
Boswellic acid + *curcuma longa* extract + bromelain extract (as Tendisulfur® Forte)	*Clinical,* patients with lateral epicondylitis, shoulder tendinopathy or Achilles tendinopathy	2019	The combination of boswellic acid, *curcuma longa* extract and bromelain as Tendisulfur® Forte increased the effectiveness of extracorporeal shock wave therapy, improved functional capacity, reduced pain and NSAID intake.	2 sachets daily Tendisulfur® Forte/ 1 month, then 1 sachet daily/ 1 month	[60]
Boswellic acid + *curcuma longa* extract	*Clinical,* patients with tendinopathy	2021	The combination of Boswellic acid and *curcuma longa* extract reduced functional impairment and pain.	2 tablets twice daily / 1 month	[30]

ANNA-LENA MÜLLER, M.SC.

is PostDoc in the lab of Dr. Mehdi Shakibaei at the Department of Anatomy I at LMU Munich. Her research focuses on treatment of tendinopathies with phytopharmaceuticals.

ARANKA BROCKMÜLLER

is a medical PhD student in the lab of Dr. Mehdi Shakibaei at the Department of Anatomy I at LMU Munich. Her research focuses on the modulation of inflammation by phythopharmaceuticals.

DR. CHRISTOPH SCHMITZ M.D.

is Head of the Department of Anatomy II at LMU Munich and scientific advisor to the sportärztezeitung.

DR. MEHDI SHAKIBAEI

is Professor at the Department of Anatomy I at LMU Munich and is a world-leading expert in fundamental research on the modulation of inflammation of the musculoskeletal system using phytopharmaceuticals.

As with phytopharmaceuticals, the use of ESWT has been shown to contribute to tendon regeneration, by substantially enhancing the expression of tendon-specific molecules such as scleraxis, thereby inducing an anabolic effect in the tissue [64]. Based on the similar effects of ESWT and phytopharmaceuticals, an initial study (on tendinopathy of the Achilles tendon) in which ESWT was combined with bromelain actually showed a synergistic effect of the two treatments, with bromelain enhancing the mode of action of ESWT [33]. A similar outcome was also achieved in a further study in which boswellic acid and curcumin extracts were administered concomitantly in the treatment of various tendinopathies (Achilles tendon, tennis elbow, supraspinatus tendon) with ESWT. Improved and more rapid regeneration with a consequent reduction in NSAID intake was also reported in this study compared to the control group, who only received treatment with ESWT [60].

CONCLUSION

In summary, due to its enhancement of anabolic effects, combination therapy involving the use of both ESWT and phytopharmaceuticals such as bromelain, curcumin and boswellia is a promising perspective, the full potential of which is currently only just beginning to be understood and realized in sports medicine. Due in particular to their low or even zero toxicity and the associated absence of undesirable effects, even with long-term use, phytopharmaceuticals are potentially a promising adjunct to ESWT and provide new approaches for the treatment of tendinopathy. It is therefore all the more important to verify the data discussed here also in Germany and the EU and to draw appropriate conclusions for the future treatment of tendinopathy.

Conflict of interests: in December 2021 and August 2022 the Department of Anatomy II at LMU Munich received grants from Electro Medical Systems (Nyon, Switzerland) to fund basic research into extracorporeal shock wave therapy.

The literature can be found at the Article on www.sportaerztezeitung.com

BIAsystems.cloud

Analysis and interpretation of body composition

- Interpretation of the nutritional and hydration status
- Documentation of progress history
- Individual monitoring of training and diet plans

Wobenzym®

MADE FOR MOVING MOMENTS

Supports freedom of movement

Clinically proven

Original German formula

Works with your body`s regenerative processes

3 capsules per day

Combination of bromelain, trypsin and rutin

Wobenzym® sport

TO SUPPORT REGENERATION IN SPORTS

Vegan

Gluten free

Colorant free

2 capsules per day

Combination of bromelain, tart cherry and vitamins

Wobenzym®

www.wobenzym.com

Availability of products depend on local markets