

# LER

LOWER EXTREMITY REVIEW

June 21 / volume 13 / number 6

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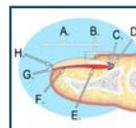
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Discussed in the literature as early as the 1500s, functioning proprioception is critical for athletes at all levels. Here we look at some recent research.



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- Injury prevention is possible
- Diabetic foot ulcers can be prevented
- Collaborative care leads to better outcomes

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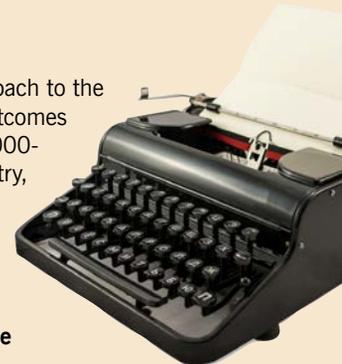
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## French Open's Treatment of Osaka Exposes Long-Buried Bias in Sport

BY VALERIE REIN, PHD

Naomi Osaka, 23, a no. 2 ranked woman tennis player is taking professional sports and athletes higher.

Leading up to the French Open, Osaka declined to participate in mandatory press conferences to preserve her mental health.

Osaka stated, "I am not a natural public speaker and get huge waves of anxiety before I speak to the world's media... Here in Paris, I was already feeling vulnerable and anxious and so I thought it was better to exercise self-care and skip the press conferences." She shared that she had been suffering from bouts of anxiety and depression since winning her first Grand Slam in 2018.

The establishment responded by issuing her a fine of \$15,000 but didn't stop there. The four Grand Slams produced a joint statement threatening Osaka with more substantial fines, possible default, and suspensions from the Grand Slams – should she continue to decline to appear at post-match press conferences. Osaka then chose to withdraw from the French Open.

Sadly, the organization's response is not surprising. In 2018, the French Tennis Federation arbitrarily banned Serena Williams from wearing a bodysuit she had custom-made to help with circulation and prevent potentially fatal blood clots at the French Open.

Differential treatment of female and male athletes across sports is notorious, such as women facing penalties for acting "emotionally" while men's far more extreme emotional outbursts go unpunished. Now we're witnessing Osaka being penalized and threatened with dire consequences by the entire tennis establishment as a response to her decision to protect her mental health from media encounters that can



be toxic.

Patriarchal and racist attitudes are insidious both in the sports establishment and the media. Osaka has been consistently questioned by the media about her race and ethnicity. One headline about her read, "How Japanese is Naomi Osaka," and she was even asked by a reporter to speak Japanese. Other female athletes have faced similar racist, sexist, and overall inappropriate questions, such as one about being compared to Serena Williams on the basis of being black (Coco Gauff), questions about her weight (Taylor Townsend), about whether her father's recent death could be blamed for her performance (Amanda Anisimova, a teenager), and a disproportionate number of questions about their personal lives and having tabloids follow their every move (Caroline Wozniacki, Maria Sharapova).

Unconscious patriarchal and racist

views, attitudes, and policies in sports take an enormous toll on female athletes' mental and emotional health and wellbeing. The micro- and macro- aggressions they face in the industry range from often being paid less than their male counterparts, to being subjected to penalties and injunctions that men are not subject to. They also face more intrusive and objectifying media coverage – why is there no Sports Illustrated Male Swimsuit edition?

This hostile environment continuously triggers a particular stress response that I have studied and termed Patriarchy Stress Disorder (PSD). For millennia, women have been suffering from the trauma of oppression under patriarchy. The field of Epigenetics has established that trauma is genetically transmitted. PSD is an intergenerational trauma of oppression that women carry in the patriarchal society.

What this means for modern women

*Continued on page 10*

is that everything that has been historically prohibited and punishable under patriarchy – authentically expressing ourselves, speaking our truth, making our own money, loving who we love – our subconscious interprets as unsafe, sending our nervous system into the fight, flight, freeze response.

It has been unsafe being a woman in the patriarchal world for countless generations. As a result, PSD has kept women in a state of chronic stress, using the fight, flight, freeze response as a survival mechanism. This response escalates the more a woman steps into her power, in her visibility and celebrity, professional success, earning larger sums of money, speaking her truth, and authentically expressing herself in front of bigger audiences. If left unaddressed, this can lead to anxiety, depression, and issues with performance and physical/health expressions. Such as Naomi Osaka.

The impact of PSD on celebrity female athletes is substantial. Female athletes of color contend with an additional layer of intergener-

ational trauma – that of racism. Just like PSD, the trauma of racism is passed down from generation to generation and is triggered by the systemic practices, attitudes, biases, micro- and macro- aggressions that these women encounter daily. The toxic impact is amplified by the limelight and increases exponentially with their success.

Everyone's mental and emotional health and implications for their physical health and performance warrants more awareness and attention. And we need to bring into the conversation – and into practice – the factors uniquely affecting women, BIPOC, LGBTQ+, and athletes who belong to other marginalized groups.

Integrating mental and emotional health training that specifically addresses the intergenerational traumas of PSD and racism is one piece of the puzzle.

Creating awareness in the corporate structures of the sports federations that tackles the persistent biases in attitudes, decisions, and

policies is another.

Naomi Osaka has advanced the global awareness of these issues. This is an opportunity to create an environment in professional sports where all athletes can truly thrive. 

*Valerie Rein, PhD, is a psychologist and women's mental health expert who has discovered Patriarchy Stress Disorder (PSD) and created the only science-backed system for helping women achieve their ultimate success, happiness, and fulfillment by healing the intergenerational trauma of oppression.*

*She holds an EdM in Psychological Counseling from Columbia University and a PhD in Psychology from the Institute of Transpersonal Psychology. She is the author of the acclaimed, bestselling book "Patriarchy Stress Disorder: The Invisible Inner Barrier to Women's Happiness and Fulfillment." Download the first chapter free at [www.drvalerie.com/book](http://www.drvalerie.com/book)*

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Case reports should be no more than 1500 words (not including references, legends, and author biographies). Photos ( $\leq 4$ ) are encouraged. Case reports can include a literature review as is appropriate for the topic. (Please note that for HIPPA compliance, photos should be de-identified before sending.)

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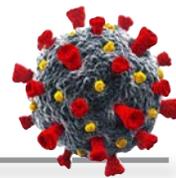
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## The Mental Impact of COVID-19 Pandemic

Despite the smoldering nature of the global COVID-19 pandemic, Americans apparently are finding some significant silver linings, according to a survey of 1,000 adults conducted for HealthInsurance.com by Scott Rasmussen in early June.

### Spotlight on Self-Care

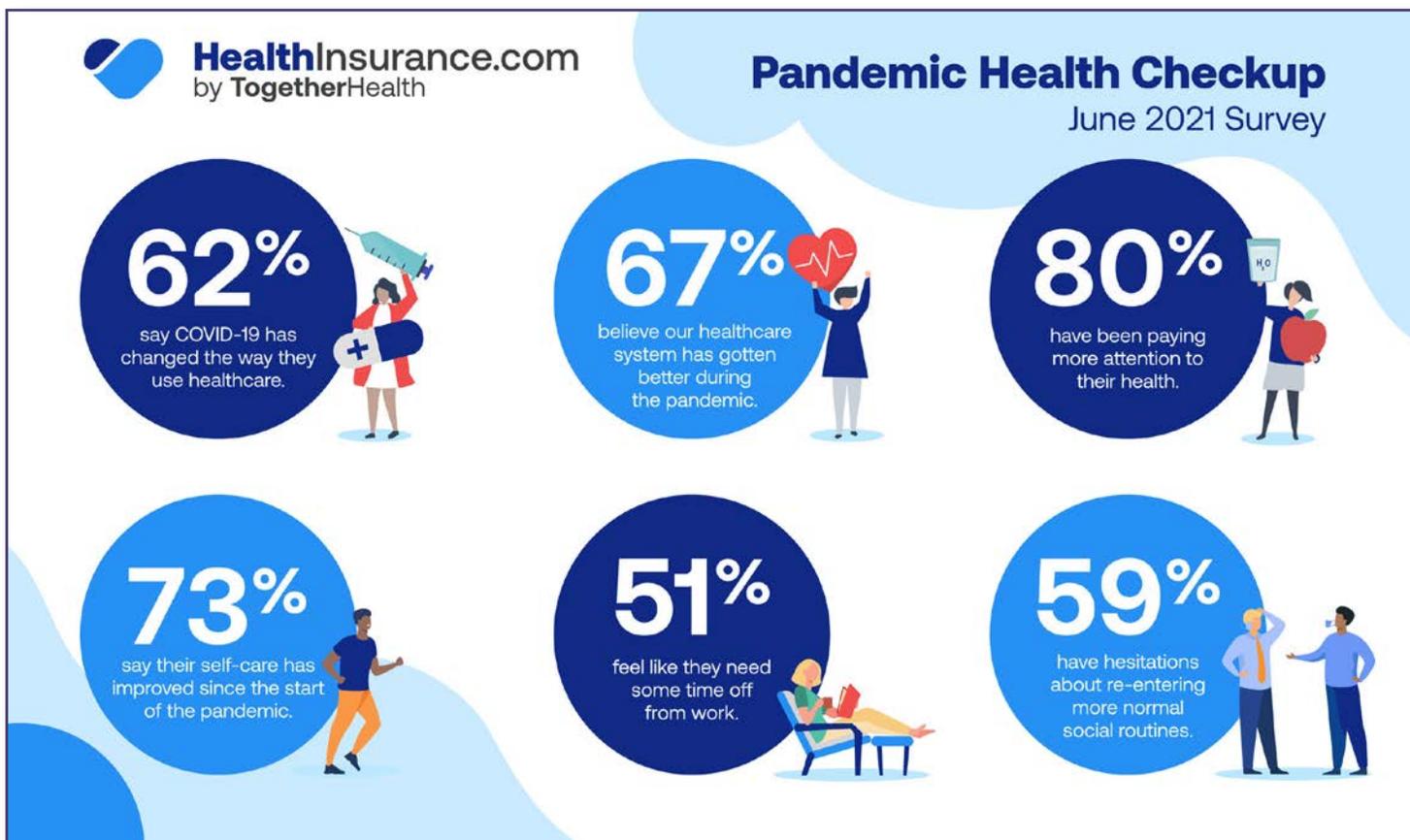
80% say they have been paying more attention to their health since the pandemic began; that's an 11% increase from June 2020. And 73% say their self-care has improved since the start of the pandemic, that's an 81% increase from the healthinsurance.com June 2020 survey. Respondents are more self-aware and acting on it. Last month, 55% say they have packed on some "pandemic pounds", and now 49% say they are dieting for this summer season. The past 15 months of pandemic life have also taken a toll. 51% feel like they need some time off from work, that's a 22% increase from this time last year. Those surveyed are acting on that need for a break with 78% planning to travel this summer.

### "Re-entry" Reservations

80% of the respondents of this survey received the COVID-19 vaccine. Of those, 48% are still worried about contracting COVID-19 even though they are vaccinated. 77% are still wearing a mask in public. 59% have hesitations about re-entering more normal social routines. Those hesitations aren't preventing them from trying though; 54% have visited a shopping mall; 59% have resumed going to restaurants and or bars; 38% have resumed travel; 58% have started going to other people's houses; 60% feel comfortable resuming travel for work.

### Evolving Healthcare

67% believe the U.S. healthcare system has improved since the pandemic began. 62% say COVID-19 has changed the way they use healthcare; a 25% increase from June 2020. That change can most likely be attributed to rapid adoption and 422% increase in telemedicine since March 2020. Some demographics have been more enthusiastic about these new options. 72% of men and 74% of 18-34 year olds say COVID-19 has changed the way they use healthcare. In fact, 81% of men say they will continue to use telemedicine. How consumers are monitoring their health is also changing. 52% are using wearables like a FitBit or an Apple Watch; that's a 24% increase from this time last year. 



Continued on page 14

## Potential Oral Treatment for COVID-19 Identified

Countries around the world are now rushing to vaccinate their populations against SARS-CoV-2, the virus that causes COVID-19. In the U.S., more than half of adults are now fully vaccinated. But new infections still occur daily. Better treatments are needed to reduce hospitalizations and deaths, and to help prevent spread of the virus.

The full genome of SARS-CoV-2 has been available to scientists since January 2020. Researchers have also used advanced microscopy techniques to map the 3D structure of the virus proteins in detail. Together, this information lets scientists search for new drugs to treat COVID-19 that are targeted specifically to its structure and functions.

In a new study, a research team led by Tracey Rouault, MD, from NIH's Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) looked for new ways to target an enzyme produced by SARS-CoV-2 called RNA-dependent RNA polymerase (RdRp).

SARS-CoV-2 needs RdRp to copy its genetic material once it's gained entry into human cells. Shutting down RdRp could potentially stop viral replication and prevent disease progression. The results were published recently in *Science*.

Previous studies of the SARS-CoV-2 RdRp structure suggested that it requires zinc to do its job. However, clusters of iron and sulfur (Fe-S), which are less stable, can fill the same structural role. The team analyzed the sequence of RdRp to identify two potential sites for such Fe-S clusters. They then showed that iron and sulfur, not zinc, are needed at these sites

for the protein to function optimally. When the researchers eliminated Fe-S clusters from RdRp, the ability of the enzyme to copy the virus's genetic material was impaired.

Since Fe-S clusters are fragile, the researchers next tested whether they could be degraded by drugs. The team focused on a drug called TEMPOL, which can break up Fe-S clusters. TEMPOL has previously been tested for other uses in people and does not appear to have serious side effects.

The researchers found that TEMPOL inhibited RdRp when tested in human cells. Next, they infected cells with SARS-CoV-2 and administered TEMPOL. The drug blocked the virus from replicating. This inhibition was seen at doses that animal studies of TEMPOL in other diseases have shown could be achieved in tissues such as the lungs and salivary glands after oral administration.

"Given TEMPOL's safety profile and the dosage considered therapeutic in our study, we are hopeful," Rouault says. "However, clinical studies are needed to determine if the drug is effective in patients, particularly early in the disease course when the virus begins to replicate."

The study team plans on conducting additional animal studies with TEMPOL. They are also seeking opportunities to evaluate it in a clinical study of COVID-19. 

*Source: Maio N, Lafont BAP, Sil D, Li Y, Bollinger JM Jr, Krebs C, Pierson TC, Linehan WM, Rouault TA. Fe-S cofactors in the SARS-CoV-2 RNA-dependent RNA polymerase are potential antiviral targets. Science. 2021 Jun 3:eabi5224.*



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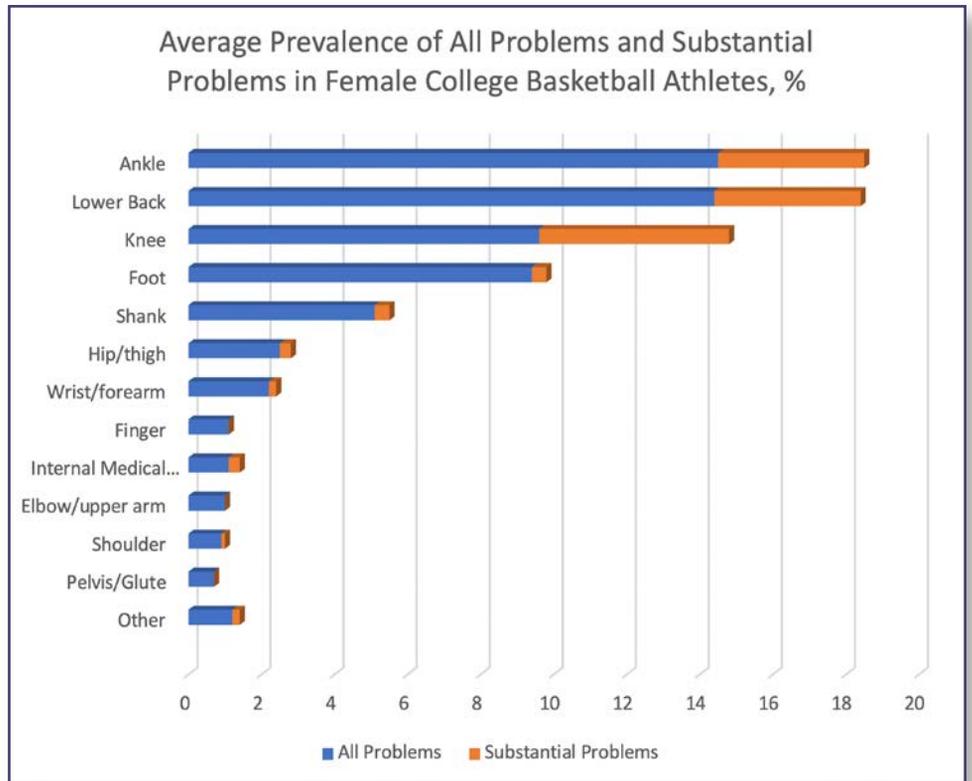


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## Ankle Leads “Problem” List for Female College Athletes

In a study out of Japan, 54 female college basketball athletes filled out the Oslo Sports Trauma Research Centre questionnaire detailing all “physical complaints” for 135 days. The average daily prevalence for any problem was 44%, with substantial problems accounting for 16%. The area most affected by physical problems was the ankle (14.5%), followed closely by the lower back (14.4%), and then the knee (9.6%). The knee also accounted for the largest proportion of substantial problems at 5.2%, compared to 4% for both the ankle and lower back. These 3 anatomical areas also accounted for the highest severity scores at 606 for ankle (ankle sprain most common), 600 for knee (ACL injury and return to full performance issues), and 561 for lower back (mostly overuse). 

**Source:** Nagano Y, Shimada Y, Sasaki N, Shibata M. Prevalence and burden of physical problems in female college basketball athletes: a 135-day prospective cohort study. *Open Access J Sports Med.* 2021;12:55–60.



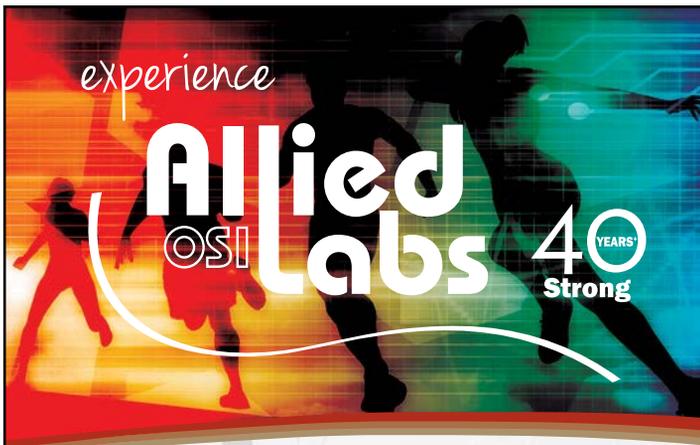
## Judo4Balance Improves Physical Functioning



Falls and fall-related injuries are major threats not only for older adults but also for younger age groups such as working-age adults. It has been shown that it is possible to reduce the risk of falls and fall-related injuries, to some extent. However, interventions that aim to reduce both the risk of falls and mitigate fall-related injuries through teaching safe falling techniques are still sparsely investigated. The aim with this study was to investigate the effect of a 10-week workplace-based judo inspired exercise program (Judo4Balance). The measures in the study include physical functions, fall-related self-efficacy, and safe falling techniques.

A total of 142 working-age adults participated in this non-randomized controlled study. The participants were allocated to the Judo4Balance group (n = 79), or to a waiting list control group (n = 63). The mean age was 47 years (18–68). The recruitment period was from May 2018 to October 2019. A total of 128 participants were included in the analysis. Logistic Regression models were used to analyze the outcomes: physical function, balance and fall-related self-efficacy as well as falling techniques (backwards and forwards).

*Continued on page 18*



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Continued from page 17

At the 10-week follow-up, the results displayed significant differences between the two groups in all measurements, except for the fall-related self-efficacy with Odds Ratio [OR] = 1.8. Techniques for falling forwards and backwards displayed the highest OR = 124.1 and OR = 98.9. Physical function and balance showed OR = 3.3 and OR = 6.4.

This exercise program under study displayed significant differences in strength, balance and safe falling techniques between the groups. It is suggested that the functions that were studied here can effectively be trained in working-age adults by using the Judo4Balance exercise program. Thus, it may be beneficial to further investigate and include training in proper falling techniques when designing fall prevention exercise programs. Furthermore, it may be a novel way of addressing fall-related injuries, which are of utmost importance to prevent in near future. <sup>(1)</sup>

*Source: Arkkukangas M, Baathe KS, Ekholm A, Tonkonogi M. A 10-week judo-based exercise programme improves physical functions such as balance, strength and falling techniques in working age adults. BMC Public Health. 2021;21:744. Use is per the Creative Commons Attribution 4.0*

**Short Breaks Help the Brain Learn New Skills**



Practice is important for learning something new. Repeating an action over and over increases the likelihood of mastering it. But recent research shows that taking short breaks may be just as critical. A 2019 study found that short, frequent breaks were key to improving perfor-

mance on a new task. These short rest periods strengthen memories of the new skill just practiced. The findings challenged the idea that only long periods of rest, like a good night's sleep, are necessary to strengthen memories of a newly learned skill. However, it wasn't clear how these short breaks help the brain master a new task. A research team led by Leonardo G. Cohen of NIH's National Institute of Neurological Disorders and Stroke (NINDS) set out to understand how short periods of rest while awake aid skill learning. Their findings were published in the journal *Cell Reports*.

The team mapped the brain activity of 33 right-handed volunteers as they learned to type a five-digit code with their left hands. Brain waves were recorded using a sensitive scanning technique called magnetoencephalography. Participants were shown a code on a screen and asked to type it out as many times as possible for 10 seconds and then take a 10 second break. They repeated this cycle 35 times.

The team analyzed the data with a computer program they developed, which allowed them to decipher the brain wave activity associated with typing each number in the code. They discovered that a much faster version—about 20 times faster—of the brain activity seen during typing was replayed during the brief rest periods.

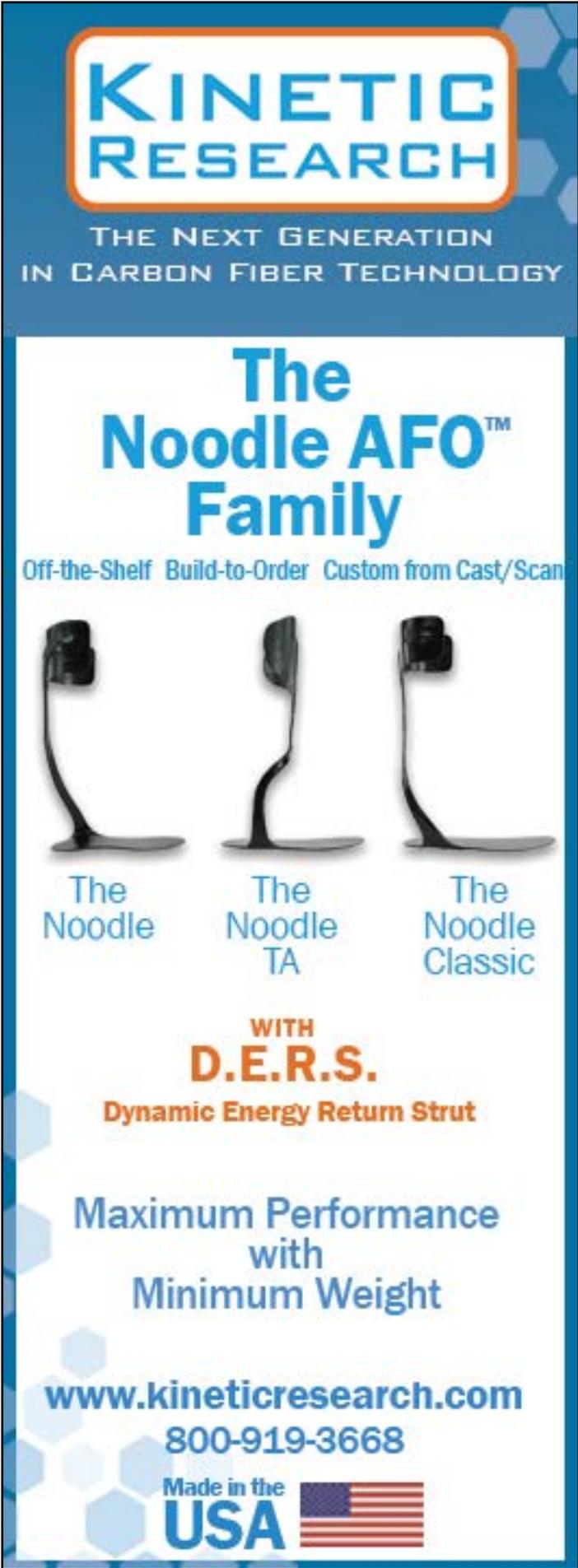
Over the course of the first 11 practice trials, these compressed versions of the activity were replayed about 25 times per rest period. This was 2 to 3 times more often than the activity seen during later rest periods or after the experiments had ended.

The researchers also found that participants whose brains replayed the typing activity more often showed greater jumps in performance after each trial than those who replayed it less often. Together, the findings suggest that brief rest periods serve to bind together the memories required to learn a new skill.

The team also examined the brain regions where replay occurred. As expected, replay activity often happened in the sensorimotor regions of the brain, which are responsible for controlling movements. However, they also saw activity in the hippocampus and entorhinal cortex. These regions were not previously thought to play a major role in the memories needed to perform new tasks.

“Our results support the idea that wakeful rest plays just as important a role as practice in learning a new skill,” Cohen said in a news release. “It appears to be the period when our brains compress and consolidate memories of what we just practiced. Understanding this role of neural replay may not only help shape how we learn new skills but also how we help patients recover skills lost after neurological injury like stroke.” 

**Source:** Buch ER, Claudino L, Quentin R, Bönstrup M, Cohen LG. Consolidation of human skill linked to waking hippocampo-neocortical replay. *Cell Rep.* 2021;35(10):109193.



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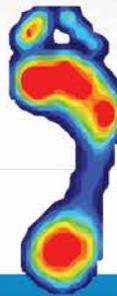
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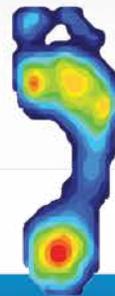
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## PREGNANCY PART 1

# Is Walking Adequate Fitness During Pregnancy?

BY TRACIE SMITH-BEYAK

There is no question that walking is generally a good form of exercise. However, it is not always appropriate during all phases of pregnancy, nor does it adequately prepare a woman for delivery or the fourth 'Tornado' Trimester. Long gone are the days of no lifting and putting your feet up during pregnancy. Pregnancy is the time to 'train' for a postnatal marathon that will last several years in a sleep-deprived state. Prenatal fitness and stamina training are essential! An optimal conditioning program should be at least 2.5 hours of exercise/week and include resistance training, weight-bearing activity, core stability training, flexibility, and pelvic floor strengthening. Biomechanical and cardiovascular modifications need to be made as the trimesters progress and regular assessment should be done. As with all things during pregnancy, do not start an exercise regimen without first consulting your physician.

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Relaxin levels increase during pregnancy creating laxity across ALL joints. The weight-bearing foot, ankle, knee, hip, and pelvis are most vulnerable during the second, third, and fourth trimesters and women quite often go up half a shoe size permanently.

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*Continued on page 22*

Over a 5-year period, a Canadian expert panel reviewed over 73,000 publications, 27,000 abstracts, completed an extensive systematic review and then released the **2019 Guidelines for physical activity during pregnancy**<sup>1</sup> (US-based recommendations are similar; see “Physical Activity Guidelines for Americans”, below). These guidelines provide ‘evidence-based recommendations regarding physical activity throughout pregnancy in the promotion of maternal, fetal, and neonatal health.’ There were **6 main messages**<sup>2</sup> within the guidelines:

1. All women without contraindication should be physically active throughout pregnancy.
2. Pregnant women should accumulate at least 150 minutes of moderate-intensity physical activity each week to achieve clinically meaningful health benefits and reductions in pregnancy complications.
3. Physical activity should be accumulated over a minimum of 3 days per week; however, being active every day is encouraged.
4. Pregnant women should incorporate a variety of aerobic and resistance training activities to achieve greater benefits. Adding yoga and/or gentle stretching may also be beneficial.
5. Pelvic floor muscle training may be performed on a daily basis to reduce the risk of urinary incontinence. Instruction in proper technique is recommended to obtain optimal benefits.
6. Pregnant women who experience light-headedness, nausea, or feel unwell when they exercise on their back should modify their exercise position to avoid the supine position.

Pregnancy appears to be associated with a permanent loss of arch height and the first pregnancy may be the most significant.

**During the pregnancy journey significant musculoskeletal adaptations take place** requiring modifications to fundamental movements such as a squat, a lunge, pushing, pulling, and lifting. Weight-bearing joints in particular are at risk for injury. ‘The hormone relaxin has a known impact on both vascular tone and connective tissue (among other areas), whereas, estrogen and progesterone activity have an impact on renal water retention and serum electrolytes concentrations. These physiologic changes have clinical ramifications that practitioners should be aware of when caring for the parturient.’<sup>3</sup> Relaxin levels increase during pregnancy creating laxity across ALL joints. The weight-bearing foot, ankle, knee, hip, and pelvis are most vulnerable during the second, third, and fourth trimesters and women quite often go up half a shoe size permanently.

Writing in a 2013 study published in the *American Journal of Physical Medicine & Rehabilitation*, Segal et al observed that ‘Pregnancy appears to be associated with a permanent loss of arch height and the first pregnancy may be the most significant. These changes in the feet could contribute to the increased risk for muscu-

## PHYSICAL ACTIVITY GUIDELINES FOR AMERICANS

Pregnant or postpartum women should do at least 150 minutes (for example, 30 minutes a day, five days a week) of moderate-intensity aerobic physical activity per week, such as brisk walking, during and after their pregnancy. It is best to spread this activity throughout the week.

Women who already do vigorous-intensity aerobic physical activity, such as running, can continue doing so during and after their pregnancy.

### ANY AMOUNT OF TIME IS FINE

We know 150 minutes each week sounds like a lot of time, but you don’t have to do it all at once. Not only is it best to spread your physical activity out during the week, but you can break it up into smaller chunks of time during the day. As long as your aerobic physical

activity is a moderate or vigorous effort, any amount of time counts toward meeting the aerobic guideline.

### ARE THERE RISKS INVOLVED WITH PHYSICAL ACTIVITY AND PREGNANCY?

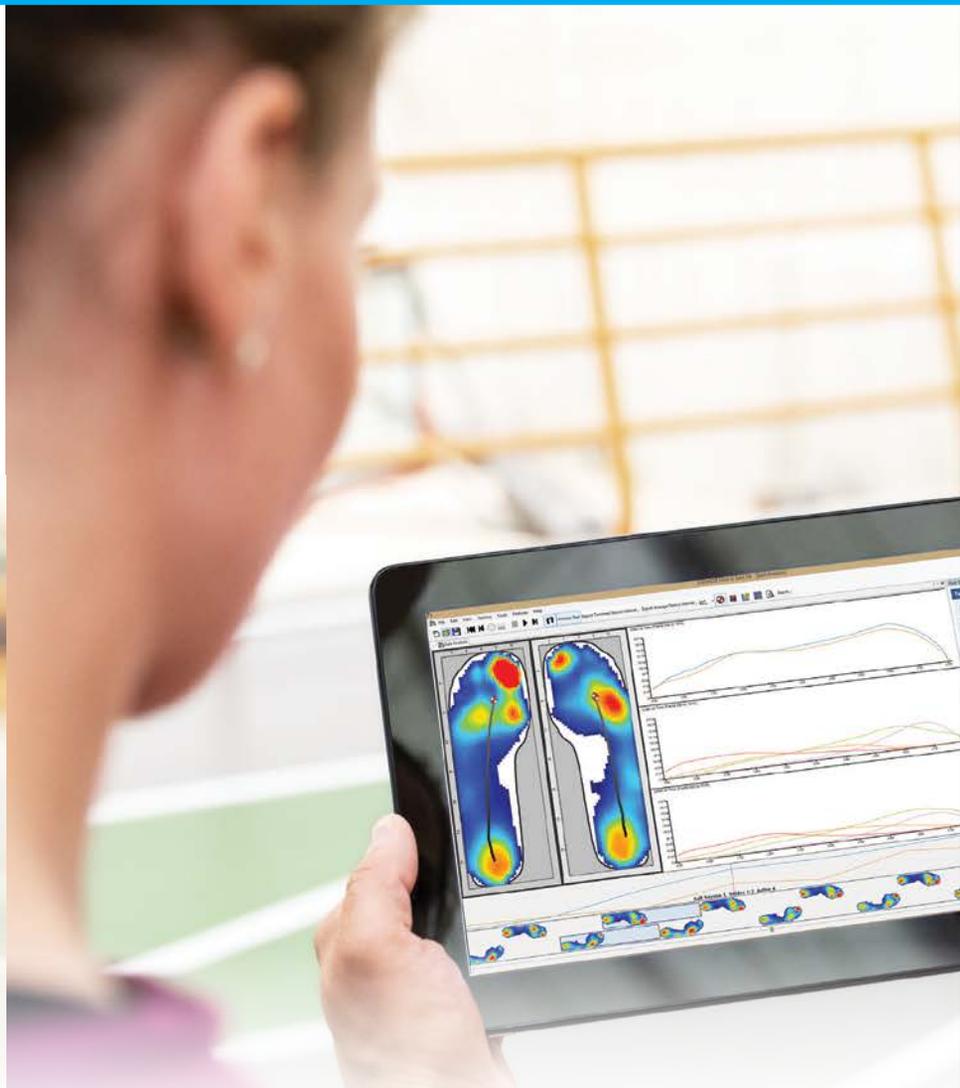
According to scientific evidence, the risks of moderate-intensity aerobic activity, such as brisk walking, are very low for healthy pregnant women. Physical activity does not increase your chances of low birth weight, early delivery, or early pregnancy loss.

### WHAT ARE SOME THINGS TO KEEP IN MIND WHEN I DO PHYSICAL ACTIVITY DURING AND AFTER MY PREGNANCY?

Unless you have a medical reason to avoid physical activity during or after your pregnancy, you can begin or continue moderate-intensity aerobic physical activity.

**Source:** U.S. Centers for Disease Control and Prevention. *Healthy Pregnant or Postpartum Women. Physical Activity Basics.* Available at <https://bit.ly/3qZ795D>. Accessed May 20, 2021.





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Continued from page 22

loskeletal disorders in women. Further research should assess the efficacy of rehabilitative interventions for prevention of pregnancy-related arch drop.<sup>4</sup> Joint laxity, center of mass shift, gait change, poor posture and lack of strength/resistance training can lead to weak joint stabilizers and diminished balance rendering the patient at increased risk of injury.<sup>5</sup>

**So, what does a clinician need to focus on with a pregnant patient/client? What type of training is appropriate?**

## The Essentials

- Take a decent history [injuries, medical conditions, meds, lifestyle, habitual environments, support, equipment, fitness level/experience, etc.].
- Have pregnant patients and their primary caregiver complete a PARQ Med X Pregnancy Screening Form<sup>6</sup> or the ACSM Information On... Pregnancy Physical Activity<sup>7</sup> and be aware of any contraindications.
- Each trimester do a basic movement assessment [squat, lunge, push, pull, lift and balance] and note gait and posture changes and mechanical errors.
- Create a program to minimize injury, strengthen main movers and target stabilizers for posture, occupation, and general functionality. Occupational and functional movement will be gleaned from the history, but don't forget to plan for life after the baby arrives. Carrying baby/baby gear, nursing, laundry, cooking, and household chores all require training for a sleep-deprived mother and should be integrated in program design.
- Listen, observe, and reassess movement regularly.

**The appropriate type of training is dictated by stage of pregnancy and each patient's particular movement patterns.** For example, for patients who regularly jog or do aerobics, there may be no change during the first trimester, but the second trimester may trigger a move to lower impact water jogging or water aerobics; programming long walks for a woman in third trimester with altered gait, arch collapse, low back pain, and tension headaches may further aggravate her discomfort. Hypothetically speaking ...Her joints may not properly articulate, her arches may further collapse under the continuous impact, the impact may also compress the lordotic curve of her lumbar spine, and hyperextension of the cervical spine combined with long period of standing could cause muscle fatigue and neck pain or headache.<sup>8</sup> In short, non-impact activities such as water walking or metabolic strength training may be better suggestions in the third trimester for cardiovascular conditioning.

Stay tuned for **Pregnancy Part 2: Targeting Prenatal Programming and a Sample Workout.**

*Tracie Smith-Beyak is an award-winning entrepreneur, master trainer, a member of the 2019-2020 Canfitpro National Fitness Advisory Panel and has worked in sports and recreation and the business industry for over 35*



years. Specializing in athletics, rehabilitation, biomechanics, and prenatal fitness, she makes regular appearances in the fitness, medical, and business sectors. She has worked internationally in government, post-secondary institutions, and the private sector. Tracie leads by example and thrives on mentoring her teams with respect, authenticity, empathy and vision.

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# Taking a Load Off: An Update on How Biomechanics Research is Shaping the Future of Conservative Treatment for Knee OA

BY MONICA R. MALY, PT, PhD

In a recent study in *The Lancet*, Cui et al estimated there are ~654 million people age 40 and older around the world who have knee osteoarthritis and an additional ~87 million individuals age 20 and older who have already been diagnosed. With such staggering numbers, understanding conservative treatments for this disease is a critical public health mandate.

Arthritis creates more pain, depression, immobility, disability, and unemployment than any other chronic condition in Canada (see “Arthritis in the United States,” page 29). The most common form is osteoarthritis (OA), which damages all tissues inside of and around moveable joints. This disorder is initiated by microscopic and joint-level injury. In response, maladaptive attempts to repair joint tissues spur on altered composition, structure and function of cartilage, bone and other joint tissues, which ultimately challenge and impair joint function.

OA affects the knee most often, likely due to its roles in weight-bearing and mobility. A greater prevalence and severity of knee OA occurs in older than younger adults and in females than males.<sup>5</sup> More than any other joint, knee OA also preferentially affects people who are



obese (body mass index [BMI] over 30 kg/m<sup>2</sup>). A dose-response relationship exists between BMI and knee OA incidence, such that those with a BMI >35 kg/m<sup>2</sup>, have a 4.7-fold elevated risk for knee OA. This dose-response relationship also suggests that reducing BMI could be a powerful tool in lowering the risk for knee OA.

In Canada, OA prevalence will reach 10 million by 2041 and healthcare costs will rise to \$8.1 billion by 2031. This dramatic increase

in burden reflects an aging and increasingly obese Canadian population. It is important to reflect that these estimates were calculated before the pandemic. While we are uncertain of the real impact of COVID-19 on OA, there is good reason to expect these older estimates will be exceeded. First, sheltering-in-place for COVID-19 has resulted in alterations in lifestyle that worsen OA risk and disease. Less exercise, more energy intake and more screen time has increased BMI among adults. Second, care opportunities for people with knee OA are more challenging to access in the pandemic.

This review provides an update on (1) guidelines for managing knee OA without drugs or surgery, (2) research trends regarding the biomechanics underlying knee OA, and (3) biomechanical strategies to reduce pain and improve wellbeing with this disease.

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Among those with a low BMI, walking fewer than 6,000 steps daily was also associated with worsening OA.

Dr. Maly's fully referenced article can be found online at [lermagazine.com](http://lermagazine.com)

Continued on page 28

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## Guidelines for Conservative Knee OA Management

In 2019, an updated set of clinical guidelines for the non-surgical management of knee OA was published by the Osteoarthritis Research Society International (OARSI). It reflects a comprehensive literature review and, very importantly, feedback from patients with OA. For the first time, these guidelines considered comorbidities common among people with knee OA: gastrointestinal problems, cardiovascular diseases, frailty, and widespread pain and/or depression. **Whether you have knee OA alone, or knee OA combined with these conditions, the OARSI guidelines strongly recommend (1) education and (2) structured, land-based exercise (strengthening/cardiovascular/balance/neuromuscular) or mind-body exercise (Tai Chi/yoga).**

These updated OARSI recommendations diverge somewhat from previous versions in 2 important ways. For the first time, mind-body exercise approaches are recommended to reflect the importance of overall wellbeing. However, some biomechanical treatments (eg, cane, knee brace) were downgraded to “conditionally recommended” because these treatments did not align with patient preferences and did not have high quality evidence of efficacy. (It is important to note that canes, braces, and shoe orthoses can also be costly and many are not reimbursed by insurance.)

These OARSI recommendations are cor-

roborated by the knee OA treatment guidelines published by the American College of Rheumatology and Arthritis Foundation (ACR/AF). Based on the literature review and patient input, the ACR/AF strongly recommends exercise, weight-management, self-management, Tai Chi, canes, and knee bracing. The ACR/AF also conditionally recommends promising interventions such as cognitive behavioural therapy and yoga, which currently lack high-quality clinical trials but may, in time, be shown helpful for people living with knee OA.

In the following, this review will examine current trends in biomechanical research, and discuss how this work could evolve conservative treatments for knee OA.

## Biomechanical Pathology of Knee OA

Research over the last 10 years has provided compelling evidence that abnormal knee loading patterns worsen knee OA and advanced our knowledge on the root causes of abnormal loading.

### *A Traditional View: Knee Adduction Moment*

Traditional biomechanics research of knee OA pathology was driven by the notion that large loads initiate and/or worsen knee OA by exceeding the capacity of joint tissues. Much work has focused on the knee adduction moment (KAM). The KAM is the torque that rotates the tibia inward on the femur, producing the typical knee deformity caused by OA: a varus

## ARTHRITIS IN THE UNITED STATES

- 54.4 million (22.7%) of adults aged 18 years or older report doctor-diagnosed arthritis
- 50% of people aged 65 or older ever reported doctor-diagnosed arthritis
- 26% of women and 19% of men ever reported doctor-diagnosed arthritis
- In 2015, 15 million adults reported severe joint pain due to arthritis
- Arthritis and other rheumatic conditions are a leading cause of work disability among US adults
  - Arthritis limits the activities of 23.7 million US adults (43.5%)
  - Around 44% of adults with doctor-diagnosed arthritis had arthritis-attributable activity limitations in 2013–2015
- Adults with arthritis were about 2.5 times more likely to have 2 or more falls and suffer a fall injury in the past 12 months compared with adults without arthritis
- In 2013, the national costs of arthritis were \$304 billion overall
  - Arthritis-attributable medical costs were \$140 billion
  - Arthritis-attributable lost wages were \$164 billion
- Osteoarthritis was the second most costly health condition treated at US hospitals in 2013

**Source:** Centers for Disease Control and Prevention. Available at <https://www.cdc.gov/arthritis/index.htm>

(or bow-legged) knee. In a static situation, the KAM can be calculated as the product of the (A) magnitude of the 3-dimensional ground reaction force vector projected upward from the point of contact under the foot and (B) the perpendicular distance between this force vector and the centre of the knee (lever arm). Traditionally KAM is thought to reflect a ratio of medial to total joint loading, where a greater KAM reflects an abnormally high proportion of loading on the medial knee compartment. Unfortunately, the more varus the knee becomes, the longer the KAM lever arm, and the greater the KAM.

Computational modeling and instrumented joint replacements (that directly measure contact forces between the tibia and femur) have challenged whether the KAM truly represents the medial contact forces that occur between the tibia and femur. These studies identify that the KAM is not a surrogate for measuring actual forces within the knee; nonetheless this quantity still proves useful. Over the last 10 years, studies conducted with different cohorts, in different

locations and over different follow-up time periods consistently show that the KAM during one walking stride predicts worsening knee tissue breakdown over time. These data provide a compelling rationale that treatments that reduce exposure to the KAM make sense for knee OA. Yet, there remains much more to learn about OA pathology beyond the KAM.

### **Multiple Biomechanical Variables Influence Knee OA Pathology**

Knee OA is also linked with altered patterns in kinematics (eg, reduced knee flexion excursion, aka knee stiffening) and kinetics (eg, elevated knee flexion moments,<sup>24</sup> flattened vertical ground reaction force curves). Muscles crossing the knee joint play a pivotal role in modulating knee loads implicated in OA. Computational modeling shows muscle contraction alters the magnitudes and distributions of joint contact forces across the knee joint surface. This work on the primary role of muscle contraction in knee joint loading emphasizes why exercise

works in reducing pain and improving wellbeing for people living with knee OA.

Additional theories have emerged.

### **Cumulative Load and Improving Joint Tissue Health**

It is theorized that all joint tissues will have a “sweet spot” (perhaps better articulated as the “sweet range”) of loading that promotes healthy structure and function; whereas chronic underloading (eg, due to inactivity) or overloading (eg, due to obesity) may both degrade joint tissues. To explore this theory, biomechanists have begun exploring cumulative loading – ie, the total exposure to loading across daily activity, rather than during a single step, as a feature in the pathway leading to OA. A recent study of 964 participants with knee OA in the Multicenter Osteoarthritis Study explored cumulative load as a mechanism for knee OA worsening. Compared to those with a low BMI (18-27 kg/m<sup>2</sup>), those with a BMI >31 kg/m<sup>2</sup> who walked a moderate (6,000-7,900) or high (>7,900) number of steps daily experienced a greater

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risk of medial knee OA worsening over 2 years, suggesting overloading could be detrimental. Importantly, underloading also increased risk. Among those with a low BMI, walking fewer than 6,000 steps daily was also associated with worsening OA. While this work points to the potential negative implications of overloading a joint affected by OA, there is also a positive viewpoint.

Despite repetitive exposure to very large peak loads during running, many studies show no elevated risk of knee OA among runners. This point is difficult to reconcile if our only concern is peak magnitudes. However, we now recognize that running also exposes the knee to low cumulative loads due to the relatively short duration of contact between the foot and the ground. This fresh perspective provides us with clues about strategies to promote knee joint tissue health by identifying the ideal range of cumulative loading. Within a healthy knee joint, more physical activity is associated with better quality cartilage. In fact, healthy young

women who were more physically active with a low BMI showed tibial cartilage more resilient to change after running. This finding may suggest that we can actually improve the quality of knee cartilage with the right amount of loading.

#### *Interactions of Biomechanics and Obesity*

Since obesity is a risk factor for knee OA incidence, it is not surprising that biomechanists are now exploring how obesity and knee biomechanics may interact to worsen knee OA. Among adults with painful knee OA, KAM predicted knee cartilage loss over 2.5 years among the obese adults, but had no impact in those with a healthy BMI. Medial tibial cartilage volume was reduced by 3.4 (6.0)% for normal/overweight and 14.1 (11.6)% for obese over this 2.5-year period. In fact, people with greater BMI have less cartilage, lower quality cartilage and softer cartilage under a mechanical load, compared to people with a normal range BMI. These data suggest that combined interventions that tackle abnormal biomechanics concurrently with reducing inflammation (eg, through prudent

diet) could multiply the effectiveness of either treatment alone.

This review will now turn focus to conservative intervention strategies with emphasis on how recent trends in biomechanics research could shape the future of conservative treatment.

## Predicting the State-of-the-Art in Conservative Mechanical Interventions

The current trends in biomechanics research inspire fresh approaches that, in time, could offer new opportunities for conservative knee OA treatment.

#### *Gait Retraining*

While too new to be currently recommended by treatment guidelines in knee OA, gait retraining is a motor learning intervention that aims to modify kinematics during gait to reduce the risk for injury. Gait retraining has poten-

*Continued on page 32*

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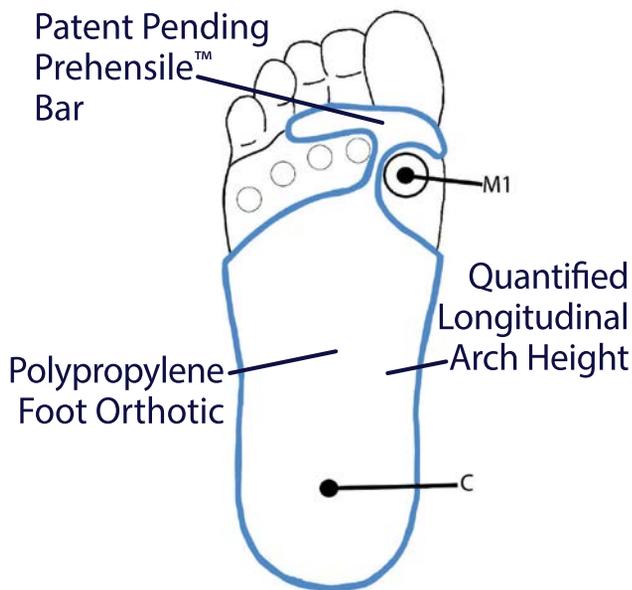
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tial for reducing KAM by shortening the lever arm for KAM. Common strategies include trunk lean (ie, shifting the body's center of mass closer to the knee), "medial thrust" (ie, forcing the knee medially during gait), and altering the foot progression angle (ie, toe-in or toe-out to apply the ground reaction force closer to the knee). To-date, data suggest that trunk lean and medial thrust gait patterns are most effective at reducing the KAM. However, many questions remain regarding implementation of gait retraining in the real-world. First, smaller sample sizes, fair to moderate study quality, variation in retraining and methodological techniques, and a relatively small number of publications to-date show that this field is still growing, without clear answers about whether these strategies will feasibly improve pain and other clinical outcomes in people with knee OA. Second, not enough data exist to evaluate the impact of altering gait on joints other than the knee. Third, methods of training, for example provision of biofeedback, vary greatly between studies with no clear recommendations on the ideal approach. Future work will provide direction to patients and clinicians regarding the potential of gait retraining for making meaningful improvements in people with knee OA.

### *Knee Bracing*

Unloader knee braces for knee OA are designed to apply external forces around the knee to redistribute internal joint contact forces away from areas of joint degeneration, most often the medial compartment. Medial compartment unloader braces effectively reduce the KAM as well as direct measurements of medial contact force. Importantly, research evidence confirms that these braces can effectively reduce pain and improve wellbeing among people with unicompartmental knee OA. Accordingly, the OARSI and ACR/AF guidelines conditionally or strongly recommend knee braces. OARSI did note, however, that patients may not adhere to brace use in the long-term, perhaps due to minor complications such as skin irritation, slipping, and poor fit. Perhaps a further consideration is that many patients with knee OA will have disease in more than one compartment. To this end, computational modelling is advancing a new idea: a knee brace that unloads the medial, lateral, and patellofemoral all at once. This approach could prove critical to expanding the number of people with knee OA who benefit from this technology.

### *Weight Management*

Traditionally, weight loss was thought to be treat knee OA simply by reducing the overall loading magnitude on the knee. For every unit of body mass lost via diet and exercise, a 4-unit reduction in compressive knee forces was observed. However, recent work has emphasized that managing obesity in knee OA likely improves the clinical picture through multiple pathways. Surgical or conservative weight loss actually improve the quality of cartilage. In the multi-centred Osteoarthritis Initiative cohort, participants who lost >5% of their body mass had slower cartilage degeneration at both 4-year and 8-year follow-up, compared to those with a stable weight. It is impressive to note these improvements were experienced even in the presence of knee OA. We now understand weight loss improves inflammatory and immune responses, which if left unchecked,

degrade tissues. Even more compelling, diet alone can improve physical function – and when diet is combined with exercise, improve physical function and pain.

However, weight loss through diet restriction is associated with a loss of lean (including muscle) mass – a loss that may disrupt the ability of muscle to modulate knee loads. Fortunately, more sophistication in dietary intervention for knee OA is on the horizon. First, the composition of food intake is important. In obese adults with risk or established knee OA, low fiber intake was associated with more severe knee pain. Following a Western diet (high in saturated fat and sugar) was associated with great risk for knee OA; while following a prudent diet (high in fish, vegetable/fruit, legumes and whole grains) lowered the risk of OA – associations that persisted even after accounting for BMI. Second, behaviours around food intake are also important. Nutrition risk screening identifies characteristics, including behavioral, that are associated with malnutrition (ie, deficiency or excess of essential nutrients). Nutrition risk screening examines risk factors such as poor appetite, physical challenges while eating such as swallowing, lack of socialization, and poor participation in meal preparation. Among Canadians with OA, those with a greater nutrition risk had poorer mobility and general health. Thinking about what you eat, and how you eat, could be important new facets in conservative OA management.

#### **Exercise**

The benefits of exercise for knee OA are established, explaining why properly prescribed exercise using multiple approaches (strength, aerobic fitness, neuromuscular, balance, and mind-body) are strongly recommended for knee OA. Very encouraging is recent data showing that strengthening can improve clinical outcomes likely without further damage to cartilage or synovial tissue (though more corroborating data are needed). OA researchers are now facing new challenges. Recent OA literature now aims to find the ideal exercise approach through direct comparison. For example, both weight-bearing and non-weight-bearing knee extensor strengthening is recommended for people with medial knee OA and comorbid obesity, though those completing weight-bearing exercise actually experienced fewer adverse events and greater improvements in health-related quality of life.

Improving adherence to treatment in chronic disease may have a greater impact on patient outcomes than any other innovation. Adherence is challenging in OA, particularly among those with pain – arguably those with the greatest need. Unfortunately, pain relief disappears after ceasing rehabilitation and only 33% of seniors with chronic conditions maintain home exercise. Technology may be a powerful antidote to poor adherence, with promising data emerging. For example, a web-based exercise program improved adherence to home exercise among patients with musculoskeletal conditions. This type of technology support of exercise is an exciting area, particularly in the context of the pandemic, to provide new avenues to keep people with knee OA moving. 

*Monica R. Maly, PT, PhD, is an associate professor in the Department of Kinesiology and Health Sciences at the University of Waterloo in Ontario, Canada.*

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# Sleep Series Part II: Sleep and Athletic Performance

BY JEREMY R. HAWKINS, PhD, LAT, ATC; MICHAEL REEDER, DO; AND ALLI POWELL, DAT, LAT, ATC

Sleep – that magical state where our bodies recuperate, our minds rejuvenate, and we are free of the everyday stresses of the world – is a necessary physiological process that all humans require. This article, the second in a series, will explore the role of sleep in performance, an area that is just now gaining traction in both sports and the business world.

Sports and exercise scientists have studied many aspects of how to improve performance, including physical training, nutrition, and supplements, as well as changes in equipment, with a significant amount of time, resources and money directed at these approaches, all with the goal to improve our capabilities. An area of more recent study in exercise science, and financial investment in both the athletic and corporate world, is sleep and its impact on performance. From the University of Oregon to the Boston Red Sox to Manchester United to Google, athletic teams and businesses are very interested in optimizing sleep for their athletes and employees in order to gain the competitive edge on the court, the field, or in business. These investments and interventions include the use of sleep pods, personalized mattresses, daily sleep-related smartphone questionnaires, and the hiring of “sleep coaches,” all in order to optimize the quality and benefits of sleep. While most of us do not have access to many of these resources, the benefits of sleep related to performance still apply to all.

Sleep is essential to many biological functions related to memory, cognition, and learning, as well as numerous physiological processes. This has been recognized since ancient times but has become a prominent topic of discussion more recently, perhaps related to the technological advances in measurement of sleep. Although the exact mechanism of sleep related to these physical and mental functions is not clearly understood, most experts agree on the overall importance. As we had noted in our first



**Figure.** Factors that can influence, and in many cases impair, sleep in elite athletes include factors unique to the individual, their sleep hygiene, and health (blue ovals) and extrinsic environmental factors (large yellow arrows), many of which are engrained in sport

article (“Sleep Series Part I: Basics of Sleep and Its Role with Injury,” January 2021, page 37), the general reason we sleep is to allow recovery from wakefulness and prepare for the demands of the next day, making it a restorative and reparative process.<sup>1</sup> Unfortunately, when we sleep poorly for several nights, the impact spreads across very different areas of our lives, including changes in appetite regulation, immune function, cognitive impairment, and neuromotor performance, as well as fluctuations in mood/mental health.<sup>2,3,4</sup> These mental and physiological process changes impact the physical and mental performance of our daily lives.

## Sleep and Mental Performance

Regarding our mental performance, effective cognitive functioning is essential in all walks of life and adequate sleep has been shown to be imperative for optimal mental function. The loss of even a few hours of sleep has been shown to have detrimental impact on language processing, attention, working memory, inhibitory control, and decision making.<sup>5</sup> These areas have a direct effect on our executive function and memory consolidation, both of which have significant impact on our occupations and personal relationships.

These specific effects on mental function likely contribute to the findings from studies of general workers in the United States that have demonstrated evidence for loss of employee productivity and worsening performance and safety outcomes secondary to loss of sleep.<sup>6</sup> In the medical field, the hours worked by providers was first evaluated in physicians in the 1980’s. These initial studies indicated that resident physician fatigue

## What Is Sleep Debt?

Sleep debt, also called a sleep deficit, is the difference between the amount of sleep someone needs and the amount they actually get. For example, if your body needs 8 hours of sleep per night, but you only get 6—you have 2 hours of sleep debt. – *National Sleep Foundation*

Continued on page 36

negatively impacted their cognitive functioning and performance resulting in increased medical errors. In addition to having a relationship to patient health, more recently it is recognized that fatigue and lack of sleep likely impacts the health and well-being of physicians and other medical providers themselves.<sup>7</sup> Many of these initial studies in both industry and medicine looked at the impact of the “night shift” or shift work, and the research demonstrated that this disruption in sleep had a negative impact on normal circadian rhythms and caused sleep debt with multiple physiological changes, elevated risk of poor health, and increased risk to overall safety.<sup>8</sup> Within medicine, these studies led to the accrediting bodies restricting work hours for resident physicians in 2003. In some industries, these findings also have led to the promotion of sleep education, flexible work schedules, and even nap pods.

## Sports Performance and Sleep

In the athletic world, performance has long been recognized as multifaceted and many studies have focused on the importance of training, conditioning, and nutrition related to improving performance in the athlete. More recent studies that have looked at the importance of sleep and the athlete’s performance have illustrated that both increase and decrease in quantity of sleep has an effect on performance.<sup>9,11</sup> It has been recognized that in addition to the basic benefits of sleep in athletes, sleep is an important component of recovery.<sup>10</sup> Clearly, overall athletic performance is impacted by neuromotor control, cognition, motor memory, balance, and focus, and sleep can have an impact in all of these areas. In general, when looking at the benefit of sleep related to different areas of performance, most studies

have shown less effect related to single bouts of exercise or maximal performance with decreased quantity of sleep. More prominently, the most common consequences linked to performance are associated with deficits in the essential skills of many athletic contests and pursuits.<sup>9,10</sup>

## Loss of Sleep is Detrimental to Performance

When looking at the impact of impaired sleep in athletes, studies indicate that maximal measures of strength appear to have minimal change with sleep loss but sustained efforts, sports specific skills, reaction time, fine motor movements and physical recovery, appear to show the most impairment.<sup>9,10</sup>

The effect of sleep loss or deprivation has been studied in many very different sports, such as strength athletes, judo, competitive darts, swimmers, volleyball, and shooting sports. These studies have shown an interesting and varied impact on performance, such as decrease in lap times in swimmers, decline in accuracy in competitive dart throwers, changes in strike zone judgement in baseball, and a decrease in overall power in the judo athlete.<sup>11</sup>

In an interesting study which combines performance, sleep loss, and the social aspect of the athlete, Jones and colleagues looked at the tweeting behavior of 90 NBA players and showed that late night tweeting was associated with a decrease in points scored and shooting percentage.<sup>12</sup>

## Sleep Extension Improves Performance

In contrast, while there are methodological challenges when evaluating sleep in general and the impact of sleep extension, the majority of the research related to sleep extension has demon-

strated the benefits for the athlete. For example, Mah et al had Division I basketball players purposefully increase their sleep quantity to 10 hours in bed per night. The athletes reported improved subjective feelings of physical and mental well-being and had improved sprint times and shooting percentage.<sup>13</sup> Another similar study evaluated the effect of increase in sleep time with a collegiate tennis team and found that the increase in sleep quantity was related to an improvement in service accuracy.<sup>14</sup> In studies involving baseball players, a small increase in average sleep time over 5 days improved visual attention and cognition, essential skills for success as a hitter in baseball.<sup>15</sup> In a professional rugby pre-season training camp, Swinbourne et al showed that a sleep extension program resulted in improved total sleep time and quality as well as improved reaction time. In addition, they also found beneficial changes in stress hormone expression in the rugby athletes, which would be important to performance, recovery, and overall wellness.<sup>16</sup>

In addition, sleep extension has been considered in professions where there are unique sleep circumstances and work demands, such as military, law enforcement, and fire fighters, who are sometimes called “tactical athletes.” As an example, in a study looking at young ROTC participants, participants undergoing a sleep extension intervention demonstrated improved executive functioning, motivation, and psychomotor vigilance.<sup>17</sup>

## Recovery or Extra Benefits?

One of the very interesting parts of this research brought up by Kutscher and Silva, is that it is unclear whether the benefits of extra sleep are from recovery of a baseline sleep deficit or does extra sleep provide physiological benefits to im-

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# What Is Sleep Quality?

Generally, good sleep quality is defined by the following characteristics: (1) You fall asleep soon after getting into bed, within 30 minutes or less. (2) You typically sleep straight through the night, waking up no more than once per night. (3) You’re able to sleep the recommended amount of hours for your age group. (4) You fall back asleep within 20 minutes if you do wake up. (5) You feel rested, restored, and energized upon waking up in the morning.

– *National Sleep Foundation*

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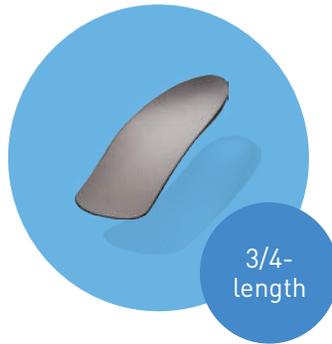


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prove performance. These authors point out the many challenges of evaluating sleep, concerns regarding how it is analyzed, and the normal variation that is found with sleep in individuals, all of which make sleep extension or “sleep banking” evaluations challenging.<sup>18,1</sup>

While there is reasonably clear evidence that adequate sleep is important for optimal functioning in many walks of life, there is still much to learn about how much sleep is needed and what is the best way to evaluate sleep both during research studies and for the average person with a watch/fitness tracker that attempts to quantify their sleep. Although the application of the technique of sleep extension or banking sleep may be an important intervention in many walks of life, there is still much to learn in this area of sleep science. It is likely more important to first work on simply obtaining adequate sleep as an initial step to improve performance, no matter your occupation.

It is important to spread awareness of the importance of sleep to our family, friends, employees, and athletes to improve many physiological and psychological factors in their lives. In addition, in many avenues of life, adequate sleep may lead to improved performance, productivity, and an improved general well-being.<sup>7</sup>

So perhaps the daily nap remains very important!

Stay Tuned. The third installment in this series will cover practical suggestions to improve sleep for our patients and ourselves, including the athlete looking to optimize their performance by maximizing the benefits of sleep. 

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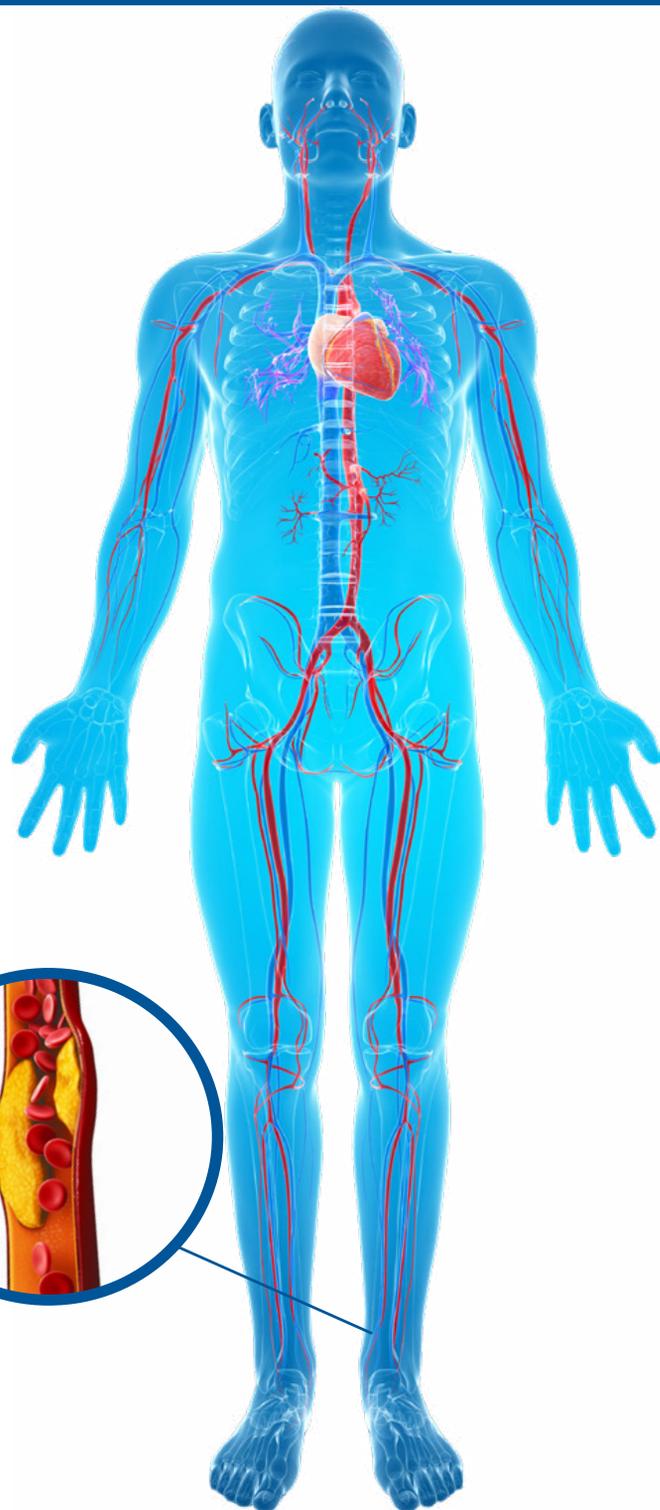
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# Recovery and Regeneration Strategies for Foot Performance: Part II

BY ANTONIO ROBUSTELLI, MSC, CSCS

In the first article of this series, I provided a general overview of the concepts of recovery and regeneration as well as terminological and methodological differences. I called it a necessary consequence of the stresses relating to training and performance. Since then, recovery has come out of the shadows. The most recent episode, Rafael Nadal's recent decision not to participate in The Championships, Wimbledon, and the Tokyo Olympics, made front-page news, bringing to the attention of the general public the importance and role of recovery in general, but also as it relates to extending an athlete's career.

In this article, I will explain why we target 3 different levels when it comes to foot recovery and regeneration, and I will outline some of the protocols we use.

The foot is a complex structure with a highly precise level of function: It must maintain proper Center of Pressure (CoP) in order to adjust for any Center of Mass (CoM) imbalances while ensuring adequate power output for performance.

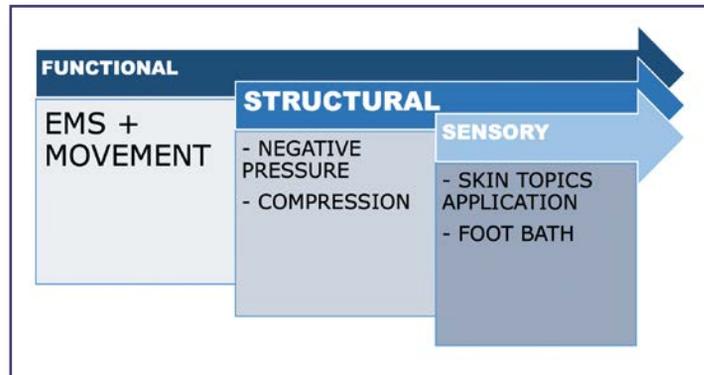
The high demands of modern sport require the implementation of recovery strategies to support the daily needs of an elite or high performance athlete. Some of the effects of the stress imposed on the musculoskeletal system by this level of training and exercise are swelling, decreased range of motion, temporary decrease in force production, muscle soreness, rise in passive tension, and increase in intramuscular proteins in blood.<sup>1,2</sup> To maintain a high-level performance, athletes' bodies must undergo a recovery period that addresses these stresses. Recovery done right leads to higher training volumes and intensities without risking overtraining and its adverse effects.

Understanding the concept of accelerating recovery is a necessary step before acritically adopting any recovery methods and strategy: In fact, the main goal of a recovery technique is to facilitate and accelerate the process of adaptations and not to interfere with its natural biological path. A second necessary step is understanding the considerable individual variability of each athlete and that each exercise/training/performance bout presents.

Our regeneration protocols for the feet have 3 levels:

**Functional Recovery (functional capacity recovery):** This level aims to restore the full capacity of both autonomic function and movement efficiency.

The first step is to provide a solid foundation for the brain to eliminate the perception of threat from the sympathetic nervous system (SNS) and start increasing the parasympathetic tone of rest (PNS). We start this process as part of the cool-down to give the input to slow down and put a brake (PNS) on the gas pedal (SNS) and remodulate muscle tone. Our protocol uses active recovery delivered with a blend of movements and electrical neuromuscular stimulation.



**Structural Recovery (tissue recovery):** The main goal of this level is to progressively improve the tolerance ability of tissues to handle mechanical stresses as well as accelerate the remodeling process.

In a recent paper on the role of recovery after exercise, Peake<sup>3</sup> observed that the overall goal of recovery, as an essential element of the training-adaptation cycle, is to regain homeostasis by replenishing fluids and substrates, restoring cardiovascular function and body temperature, and repairing the damaged tissues. Tissue remodeling activity during the recovery process promotes protein synthesis thanks to the biological mediation of muscle tears and damage.<sup>4</sup> Timing and type of intervention are fundamental to promote faster recovery without disrupting long-term biological adaptations.

We accomplish this process using a specific technique called negative pressure (LymphaTouch®, Helsinki, Finland) together with specific compression socks to be used overnight.

**Sensory Recovery (skin):** The sensory aspect relates to the fundamental role of the cutaneous receptors in the feet and their control and regulation of both human stance and locomotion.<sup>5</sup>

Cutaneous afferents of the foot are characterised by a high sensitivity and specificity to mechanical deformation of the skin. These deformations, whether they are caused by vibration, pressure, or stretching of the skin surface, are being transmitted through the tissue to the cutaneous afferent mechanoreceptor endings that interact with the central nervous system to modulate the excitability of motor neurons.<sup>6</sup> We use topical applications as well as foot baths with electrical stimulation to amplify the sensorial activation.

In the next article, I will guide you through specific details of each protocol and appropriate timing for each of the 3 levels.

To see the references associated with this article, please visit [www.lermagazine.com](http://www.lermagazine.com).

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# Can Proprioception Be Improved?

This 6<sup>th</sup> sense helps our body understand where it is in space and how to move in response to countless signals between the brain and millions of receptors throughout the body.

To move safely in this world, our body needs to understand where it is in the environment. Key among the players accomplishing this complex task is the special sense (some would call it the 6<sup>th</sup> sense) of proprioception, which is the awareness of joint position. Knowing what position the joint is in allows the body to determine how to move. Proprioception is joined by kinaesthesia, the knowledge of joint movement, and neuromuscular control, the efferent response to an afferent input. All 3 combine to provide dynamic stability or the functional component of movement. This article is a quick look at proprioception.

Scientists as far back as the 1550s were writing about a sense of position and movement, but it wasn't until the 1880s that the term kinaesthesia was introduced. Then in 1898, Goldscheider described proprioception as the conscious awareness of body and limbs including passive motion sense, active motion sense, limb position sense, and the sense of heaviness. And 10 years later, Sherrington introduced the term proprioception while writing of the unconscious component that controls muscle tone and posture.<sup>1,2</sup>

Proprioception works with sensory receptors throughout the body—including 400,000 proprioceptors in the feet—that are constantly sending messages through the central nervous system to the cerebral cortex and after processing are essentially ignored, or a message may be sent to the nerves to respond. In the case of movement, that message tells a lower extremity nerve to recruit a muscle for walking or running



or climbing a flight of stairs.

Researchers learned long ago that we do not have to actually “think” to make these movements in response to proprioceptive inputs. Turns out, because of the predictability of everyday movements, our minds anticipate the countless proprioceptive signals sent and received daily and only sense or “feel” something is different when there is a discrepancy between the signal actually sent and what we anticipated.<sup>1</sup> One example of this phenomenon is when you come to the bottom of what you thought was a standard set of stairs only to find yourself jolted by a short step. Your body hadn't thought about where it was in relation to all the other steps, but you became very aware of where you were in space when your foot slammed into the ground earlier than expected at the bottom. Worse is when you come to the bottom and the ground isn't where your foot expects to find it and you suddenly find yourself falling forward, your extended foot frantically trying to find the ground that it expected to be 12 inches beneath

the last step you were solidly on.

Proprioception also plays a role in dynamic postural stability, balance, motion, and orientation via its coordinated efforts with the vestibular system in the inner ear. This super-hero combo is an ideal target for both injury prevention and improved motor function. (Conversely, impaired proprioception is what the police are looking for when they ask a driver to touch their finger to their nose in a roadside sobriety test.)

## Injury and Proprioception

Because proprioception is essentially a nonstop feedback loop between the proprioceptors in the muscles and joints and the central nervous system, impairment or injury to any body part can harm this critical sense. The risk of diminished proprioception occurs as a natural part of aging, but it can be accelerated by several disease states that strike in mid- and later life, such as diabetes, arthritis, stroke, multiple sclerosis, Parkinson's disease, and Huntington's disease.

*Continued on page 44*

Herniated disks and brain injuries can also lead to diminished proprioception.

In younger crowds, injuries to joints, such as ankle or knee sprains, joint replacements, and surgical repairs, such as anterior cruciate ligament (ACL) reconstruction, are the prime culprits.

Symptoms of injured proprioception include:

- Balance issues (eg, trouble standing on 1 foot, frequent falls [even from a chair])
- Uncoordinated movements (e.g., can't walk a straight line)
- Clumsiness (eg, walking into walls, dropping things)
- Poor postural control
- Trouble recognizing the force or strength needed to complete a task
- Avoiding movements and activities due to fear of falling

What becomes clear when reviewing the

list of symptoms is that diminished proprioception leads to instability. Instability in aging leads to falls. Instability in sports leads to injury.

The good news is this: research has shown that proprioception, once injured, can be improved, and better yet, newer findings are proving that certain types of exercise can act as preventive measures.

## Proprioceptive Training & Treatments

Although there is no definitive definition of proprioceptive training, a systematic review by Joshua Aman et al from the School of Kinesiology at the University of Minnesota proposed the following:<sup>2</sup>

Proprioceptive training is an intervention that targets the improvement of proprioceptive function. It focuses on the use of somatosensory signals such as proprioceptive or tactile afferents in the absence of

information from other modalities such as vision. Its ultimate goal is to improve or restore sensorimotor function.

In the review, Aman et al<sup>2</sup> looked at 51 studies that used 5 training approaches: active movement/balance training, passive movement training, somatosensory stimulation training, somatosensory discrimination training, and combined/multiple system training. Study participants had an array of conditions and some of the included studies were for injury prevention in healthy individuals.

Overall, proprioceptive training resulted in an average improvement of 52% across all outcome measures. Applying muscle vibration above 30Hz for longer durations (i.e., min vs. s) induced outcome improvements of up to 60%. Joint position and target reaching training consistently enhanced joint position sense (up to 109%) showing an average improvement of 48%.

In their conclusion, the researchers

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observed:

**First, proprioceptive training can be effective in improving proprioceptive function: 29 of 51 studies reported improvement rates above 20%.**

**Second, longer lasting interventions seem to produce greater benefits. Training regimens lasting 6 weeks or longer tended to yield relatively higher improvements in proprioceptive and/or motor function, although somatosensory stimulation has been shown to yield very rapid gain within a single session or a few hours of intervention.**

**Third, proprioceptive training is applicable to a wide range of clinical populations. Patients suffering from proprioceptive impairment may benefit from the procedure disregarding if the cause of the impairment is neurological or musculoskeletal in nature.**

Other authors have reported specific

findings in a variety of populations: Xu et al<sup>3</sup> reported on a group of older, long-term Tai Chi practitioners who had significantly better threshold to detection of passive motion at the ankle when compared to a sedentary group as well as an active cohort. But there was no difference at the knee joint.

Likewise, Patrella et al<sup>4</sup> showed that active adults over age 60 had significantly better proprioception (as measured by reproduction of joint position procedures) when compared to sedentary adults. The authors suggested their results were indicative of activity as a factor slowing the loss of age-related proprioceptive function.

In a 6-year study of professional basketball players, a proprioception injury prevention program focused on single stance.<sup>5</sup> The program grew progressively in 2-year increments from classic proprioceptive exercises to the use of interactive electronic stations that provided quantifiable data. During the last 2 years, the

intensity and training volume increased while duration of the sessions decreased, reflecting the changing science. Results, which appeared in the *Journal of Strength and Conditioning Research*, demonstrated an 81% reduction in ankle sprains and a 78% reduction in low back pain, both of which were statistically significant. Knee sprains were reduced 65%. Overall, proprioception control improved significantly by 72%. The authors concluded that improving single-stance proprioceptive control could be an effective program for reducing ankle sprains, knee sprains, and low back pain.

## Conclusion

The research seems clear that certain types of exercise can help restore lost proprioceptive function and may be able to strengthen joints in an effort to prevent further injury, and more importantly, prevent initial injury. Those exercises should aim to:

- Improve spatial awareness

*Continued on page 46*



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- Improve balance
- Increase the sense of joint position

While there may be no single “proprioceptive” exercise that specifically improves proprioception,<sup>6</sup> exercises that build strength in these 3 capacities have an evidence base that supports their use in a variety of populations. 

*Janice T. Radak is Editor of Lower Extremity Review.*

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## THE TWO MINUTE CLUB

*By Geoffrey Little*

The critical component to building a strong athlete in all movements is balance. Whether the athlete is walking, jogging, running, changing direction, batting the ball, or fielding the ball, balance is key to proper movement.

As a coach, we have to understand if balance is improving or failing for each athlete. A standard test to understand and evaluate balance is to ask our athlete to stand on 1 leg with their eyes open for 60 seconds, and then repeat on the opposite side. If the athlete falters on 1 or both legs, the test should be implemented as a fundamental movement in their training.

Practicing balance for 5–10 minutes per day should give the necessary result in 2–3 weeks on average. Once the athlete is capable with their eyes open to balance on each leg individually for 60 seconds, we welcome the athlete into the prestigious “Two Minute Club.”

Once the “eyes open” component is mastered, the athlete is again tested with standing on 1 leg with their eyes open, but when ready, we have them close their eyes and see if they can hold that position. The goal is to have them stand on 1 leg with eyes closed for 60 seconds, then repeat on the other leg.

Why? We test this because the athlete’s proprioception will be in constant use during a game because so much is done on 1 leg. The athlete’s eyes are on the game, but it’s his feet that read the ground. If the athlete’s proprioceptive ability is good, his feet will read the ground quicker and he can move quicker. Training your proprioception ability will increase the speed at which your brain is giving messages to your muscles resulting in an increased input. Any delay in proprioception



will increase the ground contact time and that is detrimental to athletic performance.

This test can be used to train people with less-than-optimal proprioception; just have them continue to train with eyes closed until mastered. Balance and proprioception should improve fairly quickly. If progress stalls, they should seek further help from the coach and athletic trainer.

*Geoffrey Little is a junior at SUNY Plattsburgh who studies sports medicine with a future in sports rehabilitation treatment. He works with Microgate USA in Mahopac, New York.*

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## PATIENT GUIDANCE

# Common Skin and Nail Conditions of the Lower Extremity: Part 2

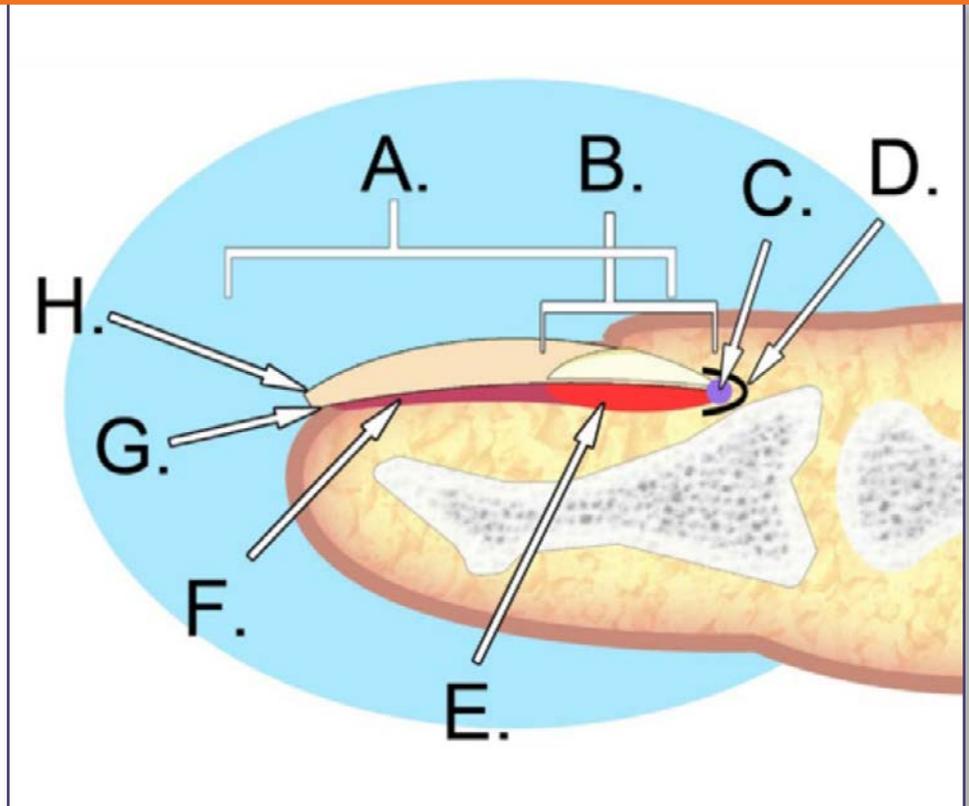
BY PAUL J. BETSCHART, DPM

Many foot and ankle specialists focus on the musculoskeletal conditions of patients. Skin and nail conditions of the feet, however, are some of the most common complaints that patients have. This 3-part series describes the most common conditions patients present with to my office and provides some effective treatment options. Part 1 of this series, which appeared last month, focused on common skin conditions. Here we will focus on issues with toenails. Part 3 will focus on conditions related to systemic disease.

### Nail Fungus

Nail fungus or onychomycosis is one of most common conditions we treat in podiatry offices. Fungal infections of the nail unit can result in changes of the appearance and quality of the nail plate. The nail plate often becomes discolored, thick, and brittle. Fungal infections usually begin with a break in these barriers through trauma, such as stubbing the toe or cutting nails too short. The fungal organisms gain access to the under surface of the nail and start to grow using the nail plate as food. Keratotic debris that forms can lift up the nail plate further allowing the fungal organisms to spread to more of the nail. If the infection reaches the nail root, nail growth is disrupted, resulting in thickening and irregularity of the nail plate. The fact that the infection is largely under the nail plate makes treating this condition difficult with topical agents alone. A variant of fungal nail infections, white superficial onychomycosis, occurs on the top surface of the nail. This can be easier to treat with topical medications.

The most common class of fungi that causes nail infections are the dermatophytes, meaning, skin lovers. They are the same class of fungi that cause skin fungal infections such as athlete's foot and ringworm. Other, less common organisms that cause nail infections are



**Figure.** A. Nail plate; B. lunula; C. root; D. sinus; E. matrix; F. nail bed; G. hyponychium; H. free margin. Image by KDS444. Use is per the Creative Commons license CC BY 3.0.

saprophytes and yeasts. Diagnosis of infecting organisms is important for guiding treatment decisions. The most accurate testing available today uses genetic sequencing to screen for many different organisms. These tests are very sensitive, requiring small sample amounts. Current testing can identify bacterial involvement as well. Microscopic evaluation can confirm the presence of fungal organisms and rule out other causes of nail dystrophy or disorder.

Treatment of nail fungal infections is usually multimodal. Reducing nail thickness by debridement can help reduce fungal load, enhance topical agent penetration, help reduce symptoms, and improve nail appearance. Topical antifungals such as tolnaftate 1% solution should be applied to the nails 1 – 2 times daily. Penetrating agents such as urea, can help improve the effectiveness of topical antifungals.

Oral antifungal therapy is usually needed for most moderate to severe infections. Modern oral agents (pills) are safe to use for most patients. Patients with active liver disease should be monitored closely by their internist during oral antifungal therapy. Safety can be improved by employing a pulsed or interrupted dosing regimen. Agents are typically taken for 1 week at a time with pulses repeated between 1 and 3 months apart. Effectiveness of pulse dosing has been shown to be similar to continuous dosing. The length of treatment varies based on speed of nail growth, with typical treatment regimens lasting 6 – 12 months. New nail grows to replace the infected nail, which is trimmed off the end as growth continues. It is important to continue treatment until the new nail grows in completely. Recurrence is uncommon after complete clearance; however, some people have

*Continued on page 50*



“Diagnosis of infecting organisms is important for guiding treatment decisions.”

a higher susceptibility to fungal infections and may need closer observation and preventative measures. The most common adverse effect that concerns most people using antifungals orally is the potential for liver toxicity. This is exceedingly rare with today's modern antifungals. Anyone with current or suspected liver disease should be considered for liver function testing prior to starting oral antifungals. Monitoring liver function tests during treatment is not necessary if using pulse dosing due to the reduced amount of medication and the interval between pulses. Patients with jaundice, unexplained abdominal pain, or white-colored stools while taking oral antifungals should have repeat liver function tests.

Oral antifungal selection should be based on testing of the nails if possible. The most commonly used oral antifungal used for nail infections is terbinafine. Other effective agents are itraconazole and fluconazole. For patients who cannot or will not take oral antifungals, other methods can be employed to attack the fungus under the nail plate, such as laser therapy. Laser devices of various wavelengths and powers have been employed for nail fungus. In my practice, photodynamic therapy (PDT) using exposure to low-level laser energy after application of pho-

tosensitizing dyes such as methylene blue has been highly effective for treating nail fungal and bacterial infections. PDT regimens are typically performed every 2 weeks for 2 – 4 months.

Some patients have repeatedly negative fungal cultures but may have bacteria isolated from their samples. It is unclear at this time whether this bacterial isolation represents a genuine clinical infection or a contamination. More research needs to be done on this subject. I have had success treating patients with fungal negative, bacteria positive nails using topical antibiotic compounds based on the results of genetic sequencing and resistance gene identification. Treatment with these agents is typically needed for 6 – 12 months based on rate of nail growth.

### **Ingrowing Toenail**

Ingrowing toenails are a painful condition that can affect people of all ages. Common causes of ingrowing nails include improper nail trimming, trauma to the toes, ill-fitting footwear, fungal infections of the nail, and genetic nail deformity. The usual signs of ingrowing nails are pain, swelling, and redness of the soft tissues around the nail. Drainage of clear to cloudy fluid from around the nail may be seen. Self-treatment is

usually ineffective.

Risks of delayed treatment can include spreading infection, bone infection, and even amputation. Risks are greater in people who are immuno compromised or have poor circulation. Topical and oral antibiotics are commonly prescribed; however, antibiotics alone are rarely curative. Often, the embedded nail fragment acts as a foreign body causing continued pain and swelling even after the infection is treated. Recurrence of the infection is typical without definitive treatment. Partial nail removal along with drainage of any infection is usually curative. This short procedure can be performed easily and safely in an office setting under local anesthetic. The patient or caregiver will need to perform simple wound care to the area daily for 1 – 2 weeks using topical antibiotic compounds. Oral agents are rarely needed unless the infection has spread beyond the nail area. The nail will return to normal shape within 6 months.

In patients with repeated ingrowing nails, permanent removal of the offending portion of the nail may be needed to prevent recurrence. The most common type of permanent partial nail removal is the chemical matrixectomy. This procedure combines the partial nail removal mentioned above with the application of a

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“There is controversy on whether a partial traumatic nail avulsion should be converted to complete or if the nail should be left in place to protect the nail bed.”

caustic chemical, such as phenol or sodium hydroxide, to the root area where the nail was removed to prevent regrowth of that part of the nail. Wound care as with the partial nail removal must be performed daily for 2 – 3 weeks. Other techniques to permanently correct ingrowing nails include surgical matrixectomy, radiofrequency ablation, and electric or thermal cautery of the nail root.

Non-surgical techniques to manage ingrowing nails can be effective in those cases where the nail has yet to penetrate the skin around the nail. These include filing of the nail edge, cotton packing of the nail grooves, and taping techniques to pull the skin away from the nail. In response to thickened nails, footwear may generate pressure pushing the nail into the skin. Reducing nail thickness by grinding can help reduce shoe pressure.

Managing underlying nail pathology, such as nail fungus, is also helpful. Non-invasive nail correction devices are another conservative option for addressing the ingrowing nail in its early stages. These devices are applied to the nail and provide a gentle corrective force which, over time, helps to change the shape of the nail, reducing the tendency for it to grow into the skin. The most innovative device of this type today is the Onyfix nail correction system (neubourg healthcare Inc., Toronto, Ontario). This employs an acrylic polymer that is applied to the surface of the nail. Once cured with an LED light, the hardened material exerts a corrective force on the nail as it grows. The material will remain on the nail throughout the growth cycle, typically for 6 – 8 months. Early results have been good with this device. It is especially useful in those who are not surgical candidates or those who are needle phobic.

Occasionally, chronic ingrowing toenails can be caused by underlying bone pathology. The most common bone abnormality associated with ingrowing nails is the subungual exostosis, or bone spur. These are benign growths of bone and cartilage that form on the top of the end toe bone, the distal phalanx. As these lesions get larger, they can press up under the nail bed and affect the shape of the nail. The curved nail shape and the interaction with the shoe toe box can result in chronic ingrowing nails. X-ray examination using a toe isolation technique can help make this diagnosis. Because the cartilage part of the lesion is not visible on x-ray, the lesion could be larger than what appears on X-ray. Subungual exostoses are often related to blunt trauma to the toe. Sometimes these lesions can arise without a cause. Conservative care for this issue consists of wearing higher toe box shoes and cushioning of the toe with shielding materials such as tubular foam or silicone gel. Surgical removal of subungual exostosis can be safely performed in an office setting under local anesthetic, often using minimally invasive techniques through small incisions in the tip of the toe. With very large lesions, skin plasty or removal of redundant skin may be needed to restore the shape of the toe and nail bed area. These procedures occasional require removal of the toenail prior to the procedure. Post-operative care is similar to other forefoot surgical procedures with 2 – 4 weeks in a surgical shoe and suture removal at 2 weeks. Nail regrowth after removal can take 6 months or more.

## Nail Trauma

Trauma to the nail area is a common reason for a visit to the emergency department or the doctor's office. Blunt trauma is most often the

cause, either by kicking the foot into something or dropping a heavy object on the toe. The most common resulting issue with blunt toe trauma is blood under the nail, called subungual hematoma. Bleeding under the nail can be caused by chronic toe trauma, such as ill-fitting footwear, as well as acute blunt trauma. Subungual hematoma can be very painful, often worse than the initial trauma. The trapped fluid has nowhere to go and cannot expand the nail plate. Pressure builds up and pushes in to the underlying nail bed causing pain. Rapid pain relief can be achieved by draining the fluid using a needle inserted under the nail plate from the end. This usually does not require anesthetics. Simple gauze dressings to collect any further drainage may be needed for a few days. Further treatment is based on whether there is underlying bone injury, such as a fracture. Some patients with subungual hematoma will eventually lose the toenail. A new nail will begin to grow and will eventually push off the old nail starting from the proximal nail fold area. Loosening nails should be protected from accidental tearing by securing them with tape or an adhesive bandage until they are completely loose. Removal of the partially detached nail after a local anesthetic block can remove this annoyance.

Traumatic nail avulsion is where the nail plate is forcefully detached from the nail bed. This can be part of the nail or the entire nail. These injuries will bleed a lot due to the vascular nature of the nail bed. Bleeding should be controlled with elevation and a pressure dressing. People taking blood thinners may need to seek medical attention to control bleeding with hemostatic medications. There is controversy on whether a partial traumatic nail avulsion should be converted to complete or if the nail should

be left in place to protect the nail bed. My preference is to treat all traumatic nail avulsions as complete and fully remove any partial nail avulsions under a local anesthetic block. This allows for full and accurate inspection of the nail bed for lacerations, which can then be repaired with sutures. This also allows for the ruling out of open fractures of the end toe bone. I find that new nail growth is faster and more even after total nail avulsion versus partial. Penetrating or sharp trauma to the nail area should be approached in the same manner. Nail removal is often needed in these situations to fully assess the injury and repair the damage. Nail regrowth after removal can take 6 – 12 months to return to normal. Injury to the tissues of the nail root area can result in an irregular nail surface that may be permanent.

For any trauma to the nail area, X-ray examination is indicated to evaluate for fractures of the toe bones. Open fractures should be

managed aggressively to prevent bone infection. Open fracture wounds should be vigorously cleaned under local anesthetic to remove debris and reduce contamination. Good daily wound care should continue until the wounds heal in 1 – 3 weeks. Reduction and/or fixation of fractures of the end toe bone are not typically needed. Prophylactic antibiotic treatment with a broad-spectrum agent should be used for 10 – 14 days or longer. Serial X-ray examination should be used every 2 weeks to evaluate bone healing and to look for signs of bone infection.

Nail unit trauma that results in significant tissue loss may require advanced tissue products or skin grafts to provide for wound closure. Amniotic tissue grafts and bio-engineered skin substitutes are options that can be employed in the office setting. Skin grafts, if needed, would be performed in the hospital operating room due to the need for anesthesia to obtain the donor tissue, usually from the upper thigh.

Nail irregularity after nail unit trauma is common. Many times, irregularity will resolve with natural nail turnover. In cases of chronic nail dystrophy, where infectious causes such as fungus have been ruled out, permanent total nail removal can be considered. This can provide symptomatic relief as well as improved cosmetic appearance. Calloused skin often forms over the nail bed following permanent nail removal and can look similar to an actual nail. Nail polish can even be applied to this area, although it will not last as long as when on an actual nail

Part 3 of this series, which will appear in the August issue, will focus on nail conditions that can reflect systemic disease. (ler)

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877/651-3668	barefoot-science.com	800-23-LIFTS	gwheelift.com	800/473-6682	ortho-rite.com
<b>Biomedix</b>	<b>40</b>	<b>Insightful Products</b>	<b>32</b>	<b>Ottobock</b>	<b>back cover</b>
888/889-8997	biomedix.com	insightfulproducts.com		800/328-4058	ottobockus.com
<b>Cascade DAFO</b>	<b>44</b>	<b>JMS Plastics</b>	<b>54</b>	<b>Pedlite</b>	<b>24</b>
800/848-7332	cascadedrafo.com	800/342-2602	jmsplastics.com	219/756-0901	pedlite.com
<b>CASPR Group</b>	<b>12</b>	<b>Kevin Orthopedic</b>	<b>37</b>	<b>Pedorthotic Footcare Association</b>	<b>33</b>
viruskillertechnology.org		877/SOS-FEET	kevinorthopedic.com	229/389-3440	pedorthotics.org
<b>Coyote</b>	<b>31</b>	<b>Kinetic Research</b>	<b>19</b>	<b>ProtoKinetics</b>	<b>47</b>
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# New & Noteworthy

Noteworthy products, association news, and market updates

## THRIVE ORTHOPEDICS F3 AFOS



Four years of collecting industry feedback has led to the design of the F3 AFO by Thrive Orthopedics. These lightweight carbon fiber AFOs accommodate patients with dexterity issues who need a supportive, durable device while providing for maximum energy return. The tibia-relief zone offers comfort, and the proprietary strut angle avoids malleolus contact. Benefits of the F3 AFO include Fidlock™ magnetic buckles available for simple securement; strap orientation can be easily changed; hook-and-loop materials selected for user experience; replacement and upgraded soft goods can be purchased; braces can be purchased individually, or bulk discounts are available; and new customer pricing is available with no minimum quantity. F3 AFOs are available for left or right orientation and in 5 sizes, from extra-small to extra-large, with trimmable footplates. Each F3 AFO comes with a 2-year warranty.

**Thrive Orthopedics**  
484/442-0494  
thriveorthopedics.com

## CHEETAH XCEL



The Cheetah® Xcel is a next-generation sports prosthesis that was specifically designed for explosive, short distance sprints of 100–200m, with proprietary design features intended to reduce the user's running effort and facilitate increased speed from starting block to finish line. It is an estimated one-third as powerful as a native ankle, returning approximately 90% of its energy when the athlete is running. The Cheetah's curve compresses at impact, storing energy and absorbing high levels of stress that would otherwise be absorbed by the athlete's knee, hip, and lower back. The carbon blade features a more extreme curve, and the dynamic shape allows for the foot to flex and give a powerful energy kick. A long toe provides better ground contact, while the plantar-flexed pylon handles forward progression.

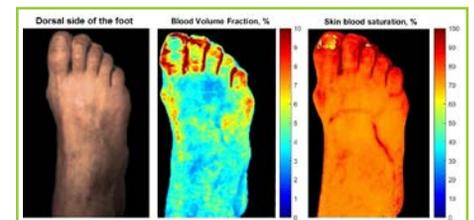
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## HYPERSPECTRAL IMAGING USED TO REVEAL DIABETIC SKIN COMPLICATIONS

A multidisciplinary research team has introduced a diagnostic approach capable of

evaluating the skin complications of diabetes. This portable optical device allows non-contact detection of possible skin complications of diabetes at an early stage, as well as the ability to perform broad population screening, explained research team member and adjunct professor Alexander Bykov, PhD, from the University of Oulu, Finland. Additionally, this method is non-invasive, is low cost, and has high resolution.

The device uses hyperspectral imaging, a technique that unites conventional imaging and spectroscopy, which was initially developed as a complex satellite or aircraft-based system. The device can remotely measure spatial maps of blood oxygen level and blood content and assess the changes in collagen structure of the skin. To achieve this, the hyperspectral imaging and polarization sensing technologies are combined and accompanied with the advanced algorithms of signal processing based on the artificial neural networks.



The system has been used to reveal early changes in skin blood microcirculation and skin structure of patients with diabetes. Image courtesy of the University of Oulu.

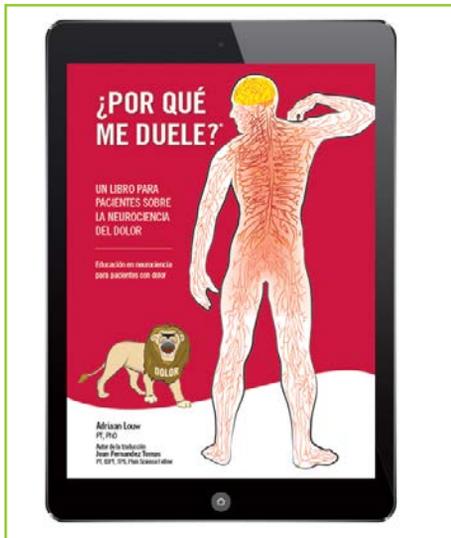
The system has been used to reveal early changes in skin blood microcirculation and skin structure of patients with diabetes. To test the process, the dorsal surface of patients' feet were imaged. It was observed that the patients with diabetes had increased skin blood content and, at the same time, reduced oxygen level in comparison to a control group of healthy volunteers. In addition, the group with diabetes had an increased polarization index that is attributed to the changes in skin collagen structure. Thus, the results of the feasibility studies, as well as the actual tests on patients with diabetes and healthy volunteers, show the

ability of the developed approach to differentiate diabetic and control groups.

Timely detection of skin disorders caused by diabetes at the early stage is crucial. Metabolic alterations at diabetes lead to the obstruction of large arteries but also impairs circulation in small vessels of the lower extremities. These changes cause complications, with diabetic foot ulcers being the major one. If left untreated, the diabetic ulcers may become infected and develop deep tissue necrosis, which may require amputation.

“Our system is potentially capable to perform monitoring of wound healing and treatment processes, including diabetic foot ulcers, skin burns, or postoperative complications associated with inadequate tissue oxygenation,” said Bykov.

### OPTP INTRODUCES WHY DO I HURT? SPANISH EBOOK



Written by pain science expert Adriaan Louw, PT, PhD, this popular book is now available as a Spanish language eBook, translated from English. Why Do I Hurt?® has helped countless individuals regain control of their lives by teaching them about the science of pain. With this new eBook, Spanish language readers can also benefit from the information and insights it offers. Studies show that the more people

know about pain and how it works, the safer they feel increasing activity through exercise, daily tasks, work, and socializing, which can help them experience less pain and can contribute to improved outcomes. Why Do I Hurt? educates pain sufferers on how the nervous system and the brain process information and contribute to the pain experience. Written in approachable language with metaphors, examples, and images, this book is an essential guide for individuals experiencing pain.

**OPTP**  
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### PREVENTING INJURIES AND IMPROVING RECOVERY WITH MICRO-DOPPLER RADARS



Penn State College of Engineering and College of Medicine researchers have developed a radar to measure subtleties in human movement. This work has implications for allowing healthcare workers to more accurately identify individuals who may be at risk for injury and to track progress precisely while individuals are recovering from an injury.

“My students and I designed and constructed the radar system to characterize the micro-Doppler features of human gait, developed and tested various classification algorithms to separate patterns from different gait types, and validated our hypothesis using measured data from athletes mimicking different gait patterns,” said Ram Narayanan, PhD, professor of electrical engineering in the

School of Electrical Engineering and Computer Science.

The system relies on the Doppler effect—a way of measuring the change in wave frequency between a target and an observer—to provide precise information about the movements of that target, in this case, the athlete. This radar system could be a cost-effective, portable, and scalable alternative to motion capture systems.

The researchers had NCAA athletes jump in front of the radar while barefoot, wearing shoes, and wearing shoes with a heel lift. The radar was able to classify the jumps into each of those 3 categories with over 90% accuracy.

“The...micro-Doppler radar is able to ‘see’ differences in human movement that the human eye is not able to differentiate,” said Cayce Onks, MS, DO, associate professor of family and community medicine and of orthopedics and rehabilitation in the College of Medicine and a physician at Penn State Health. “This type of information has the potential to be applied to hundreds of clinical applications including but not limited to prevention of falls and disabilities, early detection of Parkinson’s, early detection of dementia, concussion diagnosis, and identification of movement patterns that place individuals at risk for any number of musculoskeletal injuries such as ankle injuries and ACL tears. Other applications may include determining readiness of an individual to return to movement following rehabilitation from an injury or surgery.”

### SURGX STERILE



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## NEW & NOTEWORTHY

gical infections by destroying planktonic and biofilm encased bacteria. Using Next Science's patented, non-toxic XBIO® technology, SURGX conforms to post-operative wounds to prevent surface attachment of free-floating bacteria, eliminate pathogens in the gel, and defend against recolonization. SURGX has broad spectrum efficacy within the gel. Testing shows up to a 7-log reduction of planktonic bacteria within 2 minutes and up to 5 days of sustained efficacy against bacterial biofilms. Due to the unique mechanism of action, there is no known resistance to the technology. SURGX is 1 last line of defense against surgical site infections.

### Next Science

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## KT RECOVERY+ WAVE ELECTROMAGNETIC TECHNOLOGY FOR PAIN



KT Recovery+ Wave™ (KT Wave™) is a clinically proven, FDA-cleared wearable device that uses electromagnetic technology to provide patients a convenient, on-the-go solution for drug-free pain relief from sports injuries, knee pain, arthritis, back pain, sprains, and more. KT Recovery+ Wave uses sensation-free electromagnetic pulses, known clinically as pulsed

shortwave therapy (PSWT), to reduce nerve hypersensitivity and relieve pain. The device itself is a lightweight, discreet, flexible loop that is user-friendly: simply pull off the tab on the back of the KT Wave and press the button to turn it on. It can be secured to the body using the enclosed pieces of adhesive, centering the painful area within the loop. KT Wave works sensation-free, using PSWT to calm sensitive nerves, pulsing non-thermal, low-energy electromagnetic signals deep into tissue, muscles, and joints to target the nerves where pain is present.

### KT Tape

kttape.com

## NEUROFEEDBACK CREATES PERCEPTION OF A LIGHTER WEIGHT PROSTHESIS

Although prosthetic legs usually weigh less than half of a natural limb, their perceived weight remains a point of dissatisfaction among users. Previously, researchers led by Stanisa Raspopovic, PhD, a professor at the ETH Zurich Department of Health Sciences and Technology in Zurich, Switzerland, have shown that connecting the prostheses to the nervous system helps amputees to perceive the prosthesis weight as lower, which is beneficial for their acceptance.



Image courtesy of ETH Zurich.

Further, together with an international consortium, Raspopovic has developed prostheses that provide feedback to the user via electrodes implanted in the thigh, which

are connected to the leg nerves present there. Information from tactile sensors under the sole of the prosthetic foot and from angle sensors in the electronic prosthetic knee joint are converted into pulses of current and passed into the nerves. By artificially restoring the lost sensory feedback in this manner, Raspopovic and his team showed that wearers of such neurofeedback prostheses can move more safely and with less effort. In a further study, the scientists were able to show that neurofeedback also reduces the perceived weight of the prosthesis.

To determine how heavy a transfemoral amputee perceives the prosthetic leg to be, they had a study participant complete gait exercises with neurofeedback switched on or off. The healthy foot was weighed down with weights and the study participant was asked to rate how heavy he felt the legs were in relation to each other. Neurofeedback was found to reduce the perceived weight of the prosthesis by 23%, or almost 500 grams. The scientists also confirmed a beneficial involvement of the brain by a motor-cognitive task, during which the volunteer had to spell backwards 5-letter words while walking. The sensory feedback allowed both a faster gait as well as higher spelling accuracy.

“Neurofeedback not only enables faster and safer walking and positively influences weight perception. Our results also suggest that, quite fundamentally, it can take the experience of patients with an artificial device closer to that with a natural limb,” said Raspopovic

## THE MOTUS FOOT BY MOTUS NOVA



Motus Nova is a leader in neurorehabilitation technology with a mission to deliver high-quality

ity interventions in every home. Foot drop and other lower extremity deficits contribute significantly to impaired functionality and safety of survivors of neurologic injuries such as stroke. The Motus Foot is an FDA Class I robotic therapeutic system designed to deliver high-intensity, repetitive task practice to improve motor function in individuals in the subacute and chronic care settings. The Motus Foot has been extensively studied in peer-reviewed clinical studies and has been shown to improve gait speed and endurance and increase dorsiflexion muscle force. Moreover, Motus Nova is partnering with clinicians across the country so these systems can be used in a telehealth mode delivery. This extends the reach of their practice and helps providers offer direct access to clinically proven therapies in the comfort of their patients' homes.

#### Motus Nova

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## CITRESPLINE AND CITRELOCK LIGAMENT RECONSTRUCTION DEVICES



The CITRESPLINE™ and CITRELOCK™ Ligament Reconstruction Devices from Acuitive Technologies are intended to firmly engage tendons and ligaments within a bone tunnel while preserving the integrity of the soft tissue during insertion of the device. These products are intended to be used during orthopedic surgeries for fixation of ligament or tendon tissue repairs of the knee, ankle, foot, shoulder, elbow, wrist, and hand. The CITRESPLINE/CITRELOCK systems use the company's patented

CITREGEN™ biomaterial technology. Its main component, citrate, is a naturally occurring anti-microbial and anti-inflammatory molecule that plays a crucial role in bone regeneration, regulating cellular metabolic processes and the formation of mineral structures. CITREGEN, the core material technology, releases molecules essential to bone formation throughout its bioresorption process leaving behind a biomimetic ceramic structure to be metabolized by the host tissue. This bioresorption process avoids the potential for bulk degradation and chronic inflammation.

#### Acuitive Technologies

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acuitivetech.com

## CARESOLE CIRCA KNEE SLEEVES



Caresole's Circa Knee Compression Sleeve is professionally crafted and designed to relieve knee pain and prevent knee injuries. Made from a soft neoprene material, the sleeve keeps knees warm, helping to lubricate joints and prevent injuries. The contoured fit allows for maximum comfort, non-slip silicone strips and high-elastic fabric prevent slippage, while the state-of-the-art stabilizing technology allows a full range of motion without twisting or spraining. The sleeve features a low profile and sleek design. The metal spring stabilizers and patella gel pads help the sleeve stay in place during use. The material is light weight, breathable, stretchy, and machine washable.

#### Caresole

caresolecircaknee.io

## BIONESS ACQUIRED BY BIOVENTUS

Bioness, Valencia, CA, has been acquired by Bioventus, Durham, NC, a global company with a focus on clinically effective, cost-efficient, minimally invasive medical treatments that engage and enhance the body's natural healing processes. The acquisition cost was for \$45 million in up-front consideration, with up to \$65 million of contingent consideration related to the achievement of certain key milestones. The acquisition includes the entire portfolio of Bioness products as well as its research and development pipeline. Under the merger agreement, Bioness has become a wholly owned subsidiary of Bioventus, and all Bioness employees have become employees of Bioventus. The up-front consideration was funded exclusively through cash on hand.

## OTTOBOCK APPOINTS NEW CEO/REGIONAL PRESIDENT

Ottobock, Duderstadt, Germany, has appointed Marc C. Lundeberg as the new CEO and regional president of the company's North America



operation, headquartered in Austin, TX. He succeeds Brad Ruhl, who will remain on as non-executive chairman until he transitions to retirement after a more than 30-year tenure with Ottobock. Lundeberg joins Ottobock North America from Amplifon, where he held the position of CEO and president for North America since May 2017. Lundeberg brings expertise and a distinguished track record of strategic, operational, and people leadership to the company.



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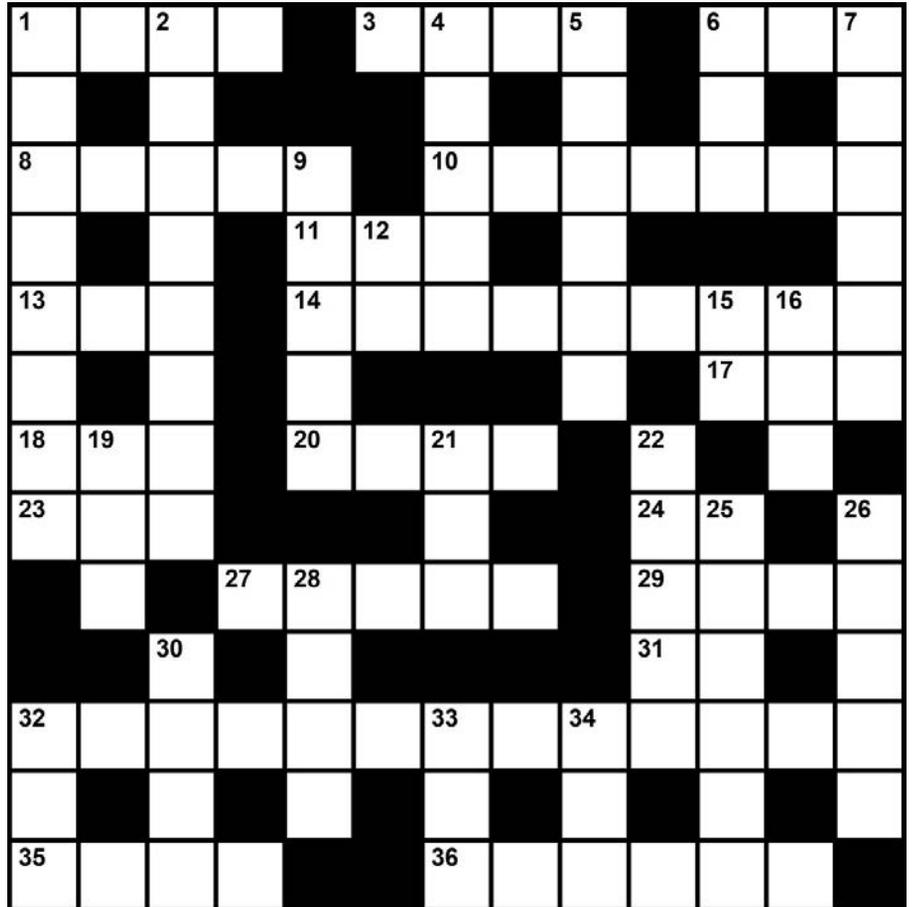


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Test your knowledge of information from this issue of *Lower Extremity Review* and the world in general with our crossword puzzle feature. The answer box can be found online at [lermagazine.com](http://lermagazine.com).



### ACROSS

- 1 Joint most commonly affected by arthritis
- 3 The M in BMI
- 6 Acronym for the torque that rotates the tibia inward on the femur
- 8 Requirements
- 10 Relating to the surface of a body part
- 11 Had a meal
- 13 Nurses' care, abbr.
- 14 Tough elastic tissue
- 17 Make a wager
- 18 Musical items
- 20 \_\_\_\_ drop: pregnancy related change in the foot structure
- 23 Observe
- 24 Over 8 hours work in a day, abbr.
- 27 Bow-legged knee
- 29 Mobility support for those suffering with arthritis
- 31 Unit of radioactivity
- 32 Relating to the branch of physics dealing with the operation of the muscles and the skeleton
- 35 Recommended discipline during pregnancy
- 36 \_\_\_\_ floor muscle training: important for pregnant women

### DOWN

- 1 Study of forces acting on mechanisms
- 2 Activity that can reduce the likelihood of developing osteoarthritis
- 4 Post
- 5 Body infection
- 6 Kilomegacycle, abbr.
- 7 Type of hammer
- 9 Spinal vertebrae
- 12 Tantalum on the Periodic Table
- 15 Least common blood type
- 16 Coalesce
- 19 Morning moisture
- 21 "Brain" of a personal computer, abbr.
- 22 Spherical bacteria
- 25 Eastern discipline recommended in the management of arthritis, 2 words
- 26 Tissue components
- 28 Square-unit measure
- 30 Extended
- 32 Shoreline indentation
- 33 Femur and pelvis connection
- 34 Nothing at all

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