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NASM-CWC

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Brandon Welch, PharmD
NASM-CWC (Expected December 2022)

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MISSION STATEMENT

THE PURPOSE

Brandon K. Welch, Pharm.D.
Founder of Pharmacy Athlete

The Sports Pharmacy magazine exists to empower a community of pharmacist professionals to optimize their impact through disseminating evidence-based knowledge and applied science on sports performance supplements and nutrition. Pharmacists can be pivotal players in the arena of sports. They are poised to help intersect biochemistry with biomechanics and real-life science with athletic performance. Our patient athletes rely on results and we are here to deliver them in real-time.

> Where Pharmacists unlock biochemistry to intersect with biomechanics to optimize patient human performance
>
> Brandon K. Welch, PharmD.

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Pharmacy™ ATHLETE

NSAIDs and Muscle Recovery

By Dr. Kristal Potter, Capt, USAF, BSC, PharmD.

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Dr. Kristal Potter is an assistant professor at the Larkin University College of Pharmacy. She received her Bachelor of Science in Neuroscience from Florida Atlantic University and her PharmD from the University of South Florida Taneja College of Pharmacy. After graduating she served as a pharmacist in the United States Air Force. During her time serving at Cannon Air Force Base she was the Pharmacy and Therapeutics Committee Chair and championed several patient education programs. Dr. Potter is passionate about holistic approaches to healthcare inspiring the next generation of pharmacy leaders.

Working in a military pharmacy, I'm no stranger to the use of ibuprofen for minor aches/pains. Use of nonsteroidal anti-inflammatory drugs (NSAIDs) is widespread in athletes and the general population. For good reason; it's accessible, effective, and can be used for a broad range of pain. At standard doses, ibuprofen has been found to be superior for pain relief compared to acetaminophen.[1] NSAIDs also come with their share of risks like peptic ulcers, renal dysfunction, and thromboembolic events.[2] Something else we need to consider when recommending NSAIDs is its impact on muscle regeneration.

Muscle Injury

Muscle injury is a broad term used to describe many injuries with different pathologies. They can be classified using a grading scale.[3] Grade I, or "mild", muscle injuries have minimal disruption to muscle cells, localized pain, and still allow a full range of motion. Grade II, or "moderate," injuries involve a greater number of muscle cells, more moderate to severe pain, and some disability/strength reduction. Grade III, or "severe", muscle injuries are considered complete muscle rupture, with diffuse severe pain and marked loss of function.

This article will focus on mild muscle injuries. These injuries can affect anyone, from the 30-year-old who hasn't played soccer since high school but decided to join a community recreational league to the elite athlete preparing for the most important game of their life. For someone who goes to the gym regularly, a muscle injury could mean missing a few workouts. For a professional athlete, a muscle injury at the wrong time could mean a missed game or event. It all depends on the timing and success of muscle recovery.

Muscle Recovery

Injured muscles have the capability of repairing themselves through myogenesis. This process of muscle regeneration consists of several stages: activation, proliferation, and differentiation of the muscle stem cells (satellite cells), and maturation/remodeling of newly formed muscle fibers.[4] Acute inflammation plays a critical role throughout this process, especially during the early stages. Mast cells and neutrophils help to clear damaged myofibers at the site of injury. The complement system recruits macrophages to aid in removing damaged cells at the site of injury. This robust system of immune cells will trigger a cascade of cellular activity to regulate muscle regeneration. This increase in inflammatory signaling pathways triggers a pro-myogenic signaling cascade which ultimately promotes the repair and remodeling of muscle cells.[4,5] This crucial pro-inflammatory phase of muscle recovery can about 1-3 days.[6] Then there is a shift towards anti-inflammatory pathways as the process continues to the repair and remodeling phases of muscle recovery.

NSAIDs and Inflammation

NSAIDs may delay muscle recovery by blunting the body's natural inflammatory process. NSAIDs inhibit cyclooxygenase (COX), an enzyme responsible for converting arachidonic acid

into thromboxanes, prostaglandins, and prostacyclins. A study by Bondesen et al found that COX-2 inhibition following muscle injury is likely to impair muscle recovery.[7] NSAIDs also cause a downregulation of prostaglandin induced stimulation of satellite cells, also decreasing muscle generation. Several animal studies have shown that NSAIDs have a negative effect on satellite cell response to exercise and decreased regeneration after exercise. Human studies have also demonstrated that NSAIDs block exercise-induced increase in satellite cells.[8] Should we reconsider the use of NSAIDs for sports related muscle injuries? There are some questions we can pose to ourselves and patients before recommending NSAIDs for a mild muscle injury.

Is the patient's pain tolerable?

Pain is a natural way to keep athletes from returning to activity too soon. When considering NSAIDs for athletes with injuries that can be exacerbated by movement, recommend mindfulness of the body's self-imposed limitations. Patients should not take NSAIDs if their goal is to "push through the pain" during a workout or activity that they should probably sit out. We don't want to mask a patient's pain enough to put them in a position to inadvertently worsen their injury. We do want to provide relief if a patient is feels like their pain is intolerable or affecting their quality of life.

Which NSAIDs should be used for mild muscle injuries?

The Bondesen et al study also noted that the potency of COX-2 inhibition may have a correlation with impairing muscle recovery. When comparing the recovery of a localized muscle injury in mice treated with either COX-1 or COX-2 inhibition, the COX-2 treated mice had decreased numbers of myoblasts and intramuscular inflammatory cells in the early stages of muscle recovery.[7] Thus, if an NSAID is recommended, non-selective COX inhibitors such as ibuprofen and naproxen may be more favorable.[8] Patients who take NSAIDs should also take the lowest dose necessary for the shortest duration possible to achieve pain relief.

When did the injury occur?

Inflammation has its most significant impact on muscle repair during the early stages of the inflammatory process.[6] Therefore, NSAIDs are less likely to affect muscle recovery in the later stages or after a few days from the initial injury. On the topic of optimal timing of NSAID usage, we should also consider the duration of therapy. NSAIDs do not need to be tapered off and a trial discontinuation is a great way to assess recovery progress. Patients should not be on NSAIDs indefinitely for a recovering muscle injury and should seek medical care if their pain persists for longer than a few weeks.[3]

NSAID Alternatives

If pain is tolerable, consider skipping the NSAIDs all together. Try the R-I-C-E method for pain relief. **Rest** by limiting activities, especially those involving the injured area. **Ice** the area using an ice bag up to eight times a day. **Compress** the injured area by keeping pressure on it to reduce swelling. **Elevate** the area above the level of the hart to reduce swelling if possible. There are also newer schools of thought on recovery acronyms, including PEACE and LOVE, highlighted in the British Journal of Sports Medicine.[9]

If adequate pain control is not achieved with non-pharmaceutical methods alone, consider acetaminophen (Tylenol) or topical preparations. Some small studies have concluded that acetaminophen is as effective as NSAIDs for pain

If adequate pain control is not achieved with non-pharmaceutical methods alone, consider acetaminophen (Tylenol) or topical preparations. Some small studies have concluded that acetaminophen is as effective as NSAIDs for pain relief following musculoskeletal injuries.

relief following musculoskeletal injuries.[10] Tylenol will not disrupt the inflammatory process in the way that NSAIDs do. Topical NSAIDs have also demonstrated effective pain relief without the systemic side effects. More serious muscle injuries may require opioids, muscle relaxants, or surgery.

Wrapping Things Up

NSAIDs are a powerful and versatile pharmaceutical option for a variety of injuries. We can safely recommend NSAIDs for managing minor muscle injury pain, but we should consider alternatives when feasible. In some situations, forgoing NSAIDs could help provide the best environment for recovery and allow the body to use its own arsenal of tools to repair and recover.

Since NSAIDs are widely available over the counter and commonly prescribed, pharmacists have a unique opportunity to counsel patients on the benefits and risks of NSAIDs. While the use of NSAIDs will not entirely impede muscle recovery, even a small delay in recovery could make a difference for amateur and professional athletes alike on a road to a speedy recovery. Given the potential side effects, even the general population can benefit from avoiding NSAIDs when it's reasonable to use alternatives.

P Protection
Avoid movement that worsens pain for 1-3 days

E Elevate
Elevate the limb higher than the heart

A Avoid Anti-inflammatories
Anti-inflammatories may affect healing

C Compression
Compression helps reduce swelling

E Education
Education can help prevent overtreatment

&

L Load
Introduce movement as soon as symptoms allow

O Optimism
Optimism is associated with better outcomes

V Vascularization
Blood flow to injury site improves physical function

E Exercise
Exercise helps restore mobility and strenth

Summarized from: *British Journal of Sports Medicine*

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The Relationship Between Sleep and Performance Recovery

By Dr. Brandon Welch, Pharm.D., M.S.(c)
Human Performance Specialist

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Dr. Brandon Welch is an experienced licensed pharmacist that holds his doctorate in pharmacy from the University of South Florida and his bachelor degree in biomedical sciences with a focus in biochemistry. His passion in performance training led him to pursue his Master's degree in physiology and kinesiology with a concentration in human performance and athletic development. His expertise lies in functional training, sports nutrition, sports medicine, genetic counseling, and sleep therapy. He utilizes science based medicine and literature to help maximize his clients training performance and daily lifestyle. He's worked with several clients, helping them lose weight, improve performance, improve their sleep cycle, muscle building, and appropriate nutrient supplementing.

The time spent training and actively building muscle has typically been seen as the most important component of an athlete's training. However, there has recently been a growing emphasis on what occurs outside the gym or training space and how it can impact an athlete's success.

One area that is showing increasing importance in athletic ability is sleep, specifically due to its role in the recovery process. In the article *The Importance of Sleep for Athletic Performance*, Marshall et al. further examined the relationship between sleep and performance recovery, and how achieving quality sleep can help athletes significantly improve their peak performance

The Role of Sleep in Recovery

The most prominent role of sleep in performance recovery lies in its promotion of hormone activity.[2]

The primary sleep hormone, melatonin, acts as an antioxidant while also activating other proinflammatory enzymes, which helps neutralize oxidative radicals that would otherwise damage cells and promote inflammation.[3] Melatonin also helps to regulate the body's circadian rhythm based on light and dark cycles, with dark cycles releasing large amounts of melatonin. When an athlete regulates their sleep with their circadian rhythm, they have an easier time falling asleep.

Sleep influences the production of other hormones as well. In stages 3 and 4 of sleep, also known as deep sleep, the body releases androgens and growth hormones, which are both crucial components of muscle building, muscle repair, bone growth, and promoting fat oxidation.[4]

Beyond these benefits that directly relate to athletic performance, sleep also promotes the restoration of the immune and endocrine systems while allowing for recovery of the nervous system and metabolic expenditure undergone while training. These actions ensure the body is ready for its next training session. Additionally, sleep stimulates memory and learning potential for the next training session.[5]

Sleep Stages

Sleep can be broken up into 5 stages, each with its own amount of consciousness and brain activity. The stages can be divided into nonREM (NREM) and REM sleep, with nonREM sleep covering stages 1-4, and rapid eye movement (REM) occurring after these stages.

The entire sleep cycle, including stages 1-4 and REM, typically takes 90 minutes and is repeated multiple times throughout the night. However, the amount of time spent in REM sleep gradually increases with each consecutive sleep cycle.

To initiate sleep, the body must be in a relaxed state for 5-20 minutes, emphasizing the need to avoid stimulating activities right before bed.

Stage 1

Stage 1 of sleep lasts between 10 seconds and 10 minutes. Awakening from sleep is highly likely in this stage because the individual is still consciously aware of environmental changes.

Stage 2

Stage 2 of sleep lasts 10 to 20 minutes and is the first stage of genuine sleep.

Stages 3 and 4

These stages of sleep last for 30 to 40 minutes and are the primary period in which growth hormone is released.[6] Once stage 4 is complete, the body repeats stages 3 and then 2 before moving into REM sleep.

REM

REM sleep is the most active stage of sleep, and once it is completed, the entire sleep cycle is repeated, up to 6 times in one sitting. REM sleep increases in duration as the night progresses, with most REM experienced within the last third of total nighttime sleep.[7]

Research Regarding Sleep and Athletic Performance

The role of extended sleep times (10+ hours per night) on athletic performance has been observed in multiple studies, with results showing improvements in basketball performance measures, faster sprint times, and improved shooting accuracy.[8, 9] All of these improvements are in addition to indirect athletic benefits such as decreased reaction times and sleepiness.

A study on 8 male subjects undergoing strength training found that sleep loss significantly reduced maximal leg press, bench press, and deadlight, and this further declined with each day of consecutive sleep loss.[10.]

Another study on 10 male team sport athletes undergoing training found how poor sleep lead to muscle glycogen depletion before exercise, contributing towards reduced performance and perception of mood state, or stress.

Beyond increasing nighttime sleeping, napping has been shown to recover sleep debt and improve athletic performance. Prior research has shown that just 30 minutes of napping can promote motor control and cognitive processes.[11] However, a key component athletes should remember when napping is that time must be provided to awaken from the nap before beginning training, although actions such as using bright light, washing the face immediately, and using caffeine can help with this process.

Sleep Recommendations for Athletes

The most significant component for sleep and athletic performance is dictating a schedule around sleep times, versus fitting in sleep times around training. This ensures that the body spends enough time in sleep, promoting greater athletic performance.

Athletes typically require 7 hours of sleep each night, although this number will differ for each individual.[12] For example, young athletes are recommended to aim for 10 hours of sleep each night to properly recover from training.[13] However, this recommendation of 10 hours of sleep has also been suggested for all athletes with long training days, regardless of age.[14]

Despite the importance of longer and better sleep, it is notoriously difficult for the athletic population to achieve. A study on German athletes found that 32% reported numerous nighttime waking's, and 79% struggled to fall asleep.[15] To combat these difficulties and achieve the necessary amount of sleep each night, it is crucial to focus on sleep hygiene.

Recommendations for better sleep revolve around two sleep factors: sleep onset and sleep duration. Improving both of these ensures a longer and higher quality night of sleep, which leads to greater recovery. Part of this is because a greater frequency and duration of REM correlates to enhanced recovery processes and optimal wakefulness during the day. In order to achieve this, it is essential to maximize sleep duration.

Ambient conditions are one area to focus on, such as the temperature of the sleeping environment. Cooler temperatures help with the onset of sleep, and temperatures that are too high may also cause nighttime wakings.[16, 17] Other conditions that promote sleep hygiene include a dark room and a lack of outside noise.[18]

Non-pharmacological agents to treat sleep

Cognitive behavioral therapy for insomnia

Cognitive behavioral therapy for insomnia *(*CBT-i*)* interventions includes stimulus control, sleep restriction to improve consolidation, cognitive restructuring, fatigue management and sleep hygiene education.

Light box therapy

Light box therapy is a type of therapy designed to treat certain sleep disorders through exposure of artificial light to help reset your circadian rhythm --- the technical term for your body clock. As a result, patient's undergoing light box therapy are able to fall asleep earlier at night, or sleep in later in the morning, improving overall sleep quality.

In particular, your doctor may recommend light box therapy if you experience sleep issues related to: Insomnia, circadian rhythm sleep disorder, seasonal affective disorder (SAD), depression, jet lag, working an overnight schedule.

Melatonin

Melatonin is a sleep hormone and antioxidant that is suggested to be associated with the control of the circadian rhythms. Melatonin is converted from serotonin and its precursor tryptophan. As light is a strong inhibitor of melatonin, almost all daily excretion of melatonin occurs at night time. Some foods are high in melatonin that may help serve as good night time relaxers before bed such as "montmemary tart cherries" or it melatonin can be taken as a supplement. If taking a supplement, it is best to take 1 hour before bed and to start on a low dose between 1-5 mg's. A handful of studies have investigated the use of melatonin in the treatment of insomnia (Morin et al., 2007). Generally, melatonin has been found to decrease subjective estimates of sleep latency and to increase total sleep time (Atkinson et al., 2003).

Tryptophan is an essential amino acid that is converted to serotonin in the brain. Through 5-hydroxytryptophan, free tryptophan is converted to serotonin, which in turn is converted to melatonin.

Tryptophan

Tryptophan is an essential amino acid that is converted to serotonin in the brain. Through 5-hydroxytryptophan, free tryptophan is converted to serotonin, which in turn is converted to melatonin. An imbalance in serotonin has been shown to be involved in the regulation of sleep processes (Markus et al., 2005), and a decrease in plasma tryptophan has been shown to produce sleep disturbances (Markus et al., 2005). This may imply that altering the ratio of free tryptophan to branched-chain amino acids may improve sleep function.

Pharmacological agents to treat sleep

Sedative hypnotics are the mainstay of insomnia treatment, but they can often be over prescribed and can be detrimental to an athlete's performance. It is preferable to reserve for when non-pharmacological treatments have failed, and to consider selecting agents with the best evidence for sleep onset and/or sleep maintenance

Non-benzodiazepines

(Eszopiclone, Zaleplon, Zolpidem)

This class of sleep agents act selectively at the benzodiazepine receptors to increase GABA and help with falling asleep. Warning signs of this drug class includes increasing an athlete's risk of CNS depression and next day mental impairment. It's best to prescribe for short-term therapy to avoid potential abuse and dependence.

Orexin-receptor antagonist

(Belsomra and Quviviq)

This class of sleep agents block the orexin neuropeptide signaling system (which promotes wakefulness) and helps you stay asleep. Warning signs of this drug class can include increasing an athlete's risk of sleep paralysis, and cataplexy-like symptoms.

Sleep: A Key Indicator in Athletic Performance

The ability of sleep deprivation to lower athletic performance by reducing the efficiency of cognitive processes and motivation, while also limiting physiological recovery responses, makes sleep a crucial component of the successful athlete's schedule.

At least 7 hours of sleep are required for athletes, although they should be customized to the individual, and many studies show improved athletic performance with those who sleep for 10 or more hours each night. This is because increasing sleep quality and duration allows the body to better perform the next day, improving athletic performance.

ABC's of Sleep Hygiene

Avoid alcohol, Blue/Bright light, and Caffeine before bed.

Alcohol – helps you fall asleep more easily, but as it is metabolized you wake up more often. ***Limit alcohol to no more than one drink with dinner (4 hours before bed).***

Blue/Bright Light – sends a signal to the brain to wake up, which we do not want before bed! Recent research has shown that both electronic devices and bright light can impact your sleep quality and delay your biological rhythm the next day making it harder to fall asleep

Caffeine – can take up to 12 hours to be metabolized and can increase arousals and time to fall asleep if taken too close to bedtime. ***If you find yourself having problems falling asleep, think about***

your caffeine consumption and if that could be the culprit. If so, set a caffeine curfew of 11 am and avoid food with hidden caffeine in the evening, such as dark chocolate.

Bedtime and wake time consistency – sleep is regulated by two processes - the homeostatic process (the longer you are awake = more pressure for sleep) and the circadian process (24h biological rhythm of alertness/drowsiness). Fluctuating bedtimes and wake times can affect both of these processes. For example, if you sleep in two hours on the weekend, both processes will be delayed by about two hours making it harder to fall asleep that evening

Cave– keep your sleep environment like a cave! Cool, dark, and quiet. Our body temperature drops as we fall asleep making it important to be cool prior to bedtime. Surprisingly a warm bath or shower will temporarily increase our body temperature, but it also quickly plummets so it is a nice precursor to sleep. Both light and sound can impact our sleep quality as well. **Use blackout shades, an eye mask, and earplugs to aid in better quality sleep. Ideally the room temperature should be between 18-20 degrees.**

Case study Sleep disorder

A 22-year old male football player presented to his primary care doctor with initial insomnia and situational anxiety. He was diagnosed with a delayed sleep phase, with a preferred sleep schedule of 12 AM to 8 AM. Attempts at going to sleep earlier resulted in a 2-hour sleep onset latency, causing anxiety over not being able to fall asleep. This was inadequately treated as a quick fix with a sedative/hypnotic (Ambien/Zolpidem 10mg nightly at bedtime). He was waking up early for training at 6 AM and having difficulty with his training regimen. Once the delayed sleep phase was treated appropriately with a seasonal affective disorder (SAD) light, which advances the sleep phase by adjusting melatonin secretion, and a 5mg dose of melatonin 30 mins before bedtime he was able to adjust his training schedule. He was than able to fall asleep earlier and wake spontaneously at 7 AM. He started experiencing major positive benefits in his training, including weight gain, improved strength, and better performance. The sedative/hypnotic medication was no longer needed once the sleep phase was advanced. Delayed sleep phase syndrome is a circadian rhythm disorder that is best treated with chronotherapy (SAD light and/or melatonin) and not a sedative/hypnotic. This case illustrates the importance of a comprehensive sleep assessment for determination of the cause of initial insomnia. Additionally, adjustment of the sleep phase improved the training regimen and response.

For more information, contact Dr. Brandon Welch, Wellness Pharmacist (Sports Medicine and Orthopedics & Executive Health Program Development)

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Applied Sports Nutrition for Athletic Recovery

By Sean Casey, RD, CSCS

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Quick Hit Summary

Nutrition is one of the primary determinants influencing an athlete's ability to recover from training sessions and ultimately, maximizing long term athletic potential. It's important for athletes to consume adequate protein (~ 0.7-1g/lb/d), dietary fats (~0.5g/lb/d) as well as carbohydrates with the later macronutrient based on caloric needs and sport training. Generally speaking, athletes should aim to eat every 3-4 hours, especially if training 2x/day. Hydration should be emphasized as well. When participating in all day or weekend tournaments, emphasis should be placed on easily digested foods with an emphasis on liquid nutrition. Nutraceuticals that may assist physical recovery include taurine (3-4g/d), collagen (~10-15g/d), Omega-3's (4g EPA +DHA) as well as addressing underlying micronutrient deficiencies.

Setting the Stage for Athletic Recovery via Nutrition

It's not how hard one trains but rather the ability to recover between training sessions that determines long-term athletic success

There are many determinants which influence the effectiveness of an athlete's recovery such as sleep, recovery modalities (hydrotherapy, compression therapy, etc), overall stress levels and daily nutrition.

In this article, I'd like to focus on the latter of these determinants, daily nutrition. More specifically we'll be addressing both amount and timing of food intake along with fluid and nutraceutical concerns.

Caloric (Kcal) Intake to Optimize Athletic Recovery

Many nutritional variables influence physical recovery. Although emphasis is often placed on protein, carbohydrates and fats, one must remember that regardless of macronutrient intake, one's ability to optimally respond to a training session will be compromised in the face of inadequate energy intake.

There are many ways to assess caloric needs. Although various estimation equations have been established, arguably the most accurate way of assessing caloric needs is by looking at Energy Availability (EA).[1] This way of assessing caloric (kcal) needs is based on the amount of energy available for the body to perform all essential functions (breathing, heart beating, etc) once the energy requirements of exercise are accounted for using the following equation:[2]

EA (energy available) = (Energy intake (EI) – Estimated Energy Expenditure (EEE)) /Fat Free Mass in kilograms (FFM)

To optimize recovery, it's believed that EA for males should be 40 ≥ kcal/kg FFM and females ≥ 45 kcal/kg FFM. For short periods of time, one may choose to use EA's of 30-40 kcal/kg FFM (males) or 30-45 kcal/kg FFM (females) to support weight loss goals.

In the absence of knowing someone's exact body fat, daily energy expenditure, I encourage athletes to each as many kcal as they can while still maintaining optimal athletic weight. One can also use the Harris-Benedict equation and apply the appropriate activity factor to estimate kcal needs. A very crude rule of thumb is 19-24 calories per pound of goal body weight.

Key take-away: Optimal energy intake is the number 1 determinant of optimizing the recoverability of an athlete & long term success.

Macronutrients – Amounts &

Timing to Optimize Athletic Recovery

Generally speaking, protein (PRO) and carbohydrates (CHO) are the two primary macronutrients of concern as it relates to recovery from training sessions. This makes sense as muscle is made of protein, highlighting its importance for recovery and carbohydrates are often one's primary source of energy during physical activity of moderate to higher intensity.

Although protein and carbohydrates often get the limelight, one should not discount the impact of dietary fats. Not only do dietary fats provide a source of energy, especially if following a ketogenic diet, but they also increase absorption of dietary antioxidants such as carotenoids.[3] Antioxidants can be thought of as nature's natural anti-inflammatories.

As a general rule of thumb, daily consumption of 0.7g PRO/lb, 0.3-0.5g Fat/lb with the remainder of calories from CHO works well for most athletes. However, tweaks may be necessary considering an athletes training volume and sport.

One should focus on eating or drinking protein containing meals every 3 to 4 hours in amounts of 20-40g.[3] Higher amounts of protein may be required if consuming plant-based proteins, due to lower amounts of the amino acid leucine. Additionally, older athletes 50-60 years of age, appear to require higher amounts of protein per serving to elicit the same anabolic response as someone in their 20's.[4]

It was once thought that protein and carbohydrates had to be consumed within the first hour post training. However, more recent research suggests that consuming adequately dosed protein meals every 3 hours, along with meeting daily protein needs, the need to consume food immediately post workout is of lesser importance.[3] That said, from a practical timing standpoint, most athletes last large pre-training meal usually takes place 1-2 hrs before training. Considering that most training sessions are 1-2 hrs in length, eating a high protein-carbohydrate meal within the first 30-60 minutes is usually optimal as this falls within the 3-4 hour meal interval.

The addition of carbohydrates to the post workout meal is important to support glycogen resynthesis.[3] In the event that one is completing multiple training sessions per day where rapid glycogen replenishment is key, it's recommended to consume approximately 0.5g CHO/lb/hr.

Below are a couple food based examples of how someone may achieve a post workout meal strategy of 20-25 g protein + 70-100g carbohydrates during first 60 minutes post exercise:

- Smoothie: 1 c yogurt + 2 bananas + 20g whey protein
- Food: 2 slices of bread + 5 oz sliced turkey/chicken/beef + glass of milk/orange juice + 1 apple

Key take-away: Protein and carbohydrates are critical for post workout recovery. Additionally, one should not forget the importance of dietary fat as this macronutrient contributes to overall energy intake and increases absorption of dietary antioxidants which support recovery. One should focus on consuming 20-40g of protein every 3-4 hours and a post workout meal focusing on both carbohydrates and protein.

Strong emphasis should be placed on daily hydration strategies as dehydration can impair recovery.

Fluid Considerations

Fluid recovery is one of the most underappreciated aspects of performance. On an acute basis, based on my 'in the field' experience, failure to properly hydrate often affects performance far quicker than a lack of nutrition will.

The effects of dehydration are especially common when two-a-day practice sessions are taking place during hot and humid weather. Additionally, failure to fully hydrate can easily take place when participating in a water based sport such as swimming as being in a pool can make it harder for athletes to sense the amount of water lost via sweat.

An easy applied way to assess water loss during practice or competition can be to weigh oneself pre and post event. For each pound of water lost during it, one should consume 1 pint of fluid. Sports or electrolyte drinks can assist the rehydration process.

As it relates to optimizing daily recovery via fluid intake, a general rule of thumb is to drink half your weight in ounces of water each day. For example, a 160 lb athlete would need to consume 80 oz of water. Another, more dynamic way of ensuring adequate fluid intake is by drinking enough fluid such that you have to go to the bathroom every 90-120 minutes and urine is relatively clear or a light yellow.

Key take-away: Strong emphasis should be placed on daily hydration strategies as dehydration can impair recovery.

Recovery During All Day/Weekend Tournaments

Many athletes compete in all day events which may involve 2-4 matches/games per tournament day.

Additionally, these tournaments may be 2-3 days in length. To promote inter-match/game recovery, it's important for athletes to maximize their glycogen stores prior to starting the competitive event. From a practical standpoint, it's dang near impossible to play catch-up during an all-day tournament depending on the nature of the sport.

Thus, it's critical to have a strategy in place to maximize nutrient intake in these situations. Emphasis should be placed on consumption of easily digestible food with emphasis on carbohydrates and protein. High fat, dairy and fiber foods can be problematic for some as they tend to digest slower in the stomach; thus, leading to GI discomfort for athletes if consumed too close to a game or match.

Liquid nutrition often works well to promote inter-match/game recovery as it not only provides macronutrients but also replenishes fluids lost during competition.

Examples of potential inter-match/game options include:
- Smoothies/protein-carbohydrate drinks
- Electrolyte sport drinks
- Bananas & low fiber fruit (< 3g fiber/serving)
- Yogurt
- Gummies/Gels
- Crackers
- Trail mix
- Fruit
- Granola/Energy bars
- Jelly Sandwiches

Emphasis should be placed on trying each of the above foods prior to a practice or training session to assess how well the athlete can tolerate them prior to trying them before or between athletic competitions.

One should NEVER try something new on a competition day.

Key take-away: In instances where athletes compete multiple times per day, emphasis should be placed on inter-match/game recovery strategies focused on replenishing fluid, electrolyte, carbohydrates and protein. These recovery strategies should be practiced prior to a training session to ensure they're well tolerated by an athlete before trying during an all-day competitive event.

Nutraceuticals to Support Athletic Recovery.

There are many nutraceuticals which may enhance physical recovery and optimize the training process. An all-encompassing in-depth look at nutraceutical support for post workout recovery is beyond the scope of this article.

However, specific to reducing performance decrements, research suggests that taurine (3-4g/d), collagen (20g/d) & fish oil (4 g EPA+DHA) may accelerate the recovery process.[6-9]

Also, it should be noted that any micronutrient deficiency (vitamin D, magnesium, etc) can greatly impact the bodies' ability to recover. Thus, emphasizing the need to test appropriate nutrients levels, teach the athlete about the results, form a therapy performance plan to improve levels and retest to ensure one is hitting their mark. At Hometown Pharmacy of Wisconsin, we refer to this as test-teach-therapy-test protocols.

Key take-away: There are many nutraceuticals that appear to support post training physical recovery including taurine, collagen and Omega-3's. Additionally, sub-optimal levels of a variety of micronutrients (vitamin D, magnesium, etc) can also influence the bodies ability to recover. Thus, emphasis should be placed on test-teach-therapy-test protocols to measure, assess, plan and retest to ensure an athlete's micronutrient levels are optimal.

Wrapping Things Up

When it comes to optimizing long term athletic performance, the name of the game is recovery. It's one's ability to recover that will influence how hard he or she can train during their next training session.

Nutrition is a key piece of the recovery process. It's important for sports pharmacists, athletic trainers, dietitians and other professionals to pay particular attention to daily calorie, macronutrient and fluid intake along with nutraceuticals to optimize an athlete's recoverability.

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Water Immersion Recovery for Athlete's

By Dr. Jessica Beal-Stahl, Pharm.D.

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An athlete's recovery is a multifaceted restorative process encompassing physiological, neurological, and psychological aspects. Recovery is a vital aspect of any physical conditioning program, but it is often overlooked and underappreciated by many athletes and coaches.

Proper recovery after training sessions is essential to improve an athlete's performance, as under-recovery leads to overreaching, burnout, and poor athletic performance.[1] Athletes seek to find the holy grail of recovery to allow for greater training loads, enhanced training effects, and improved competitive performance. But the athletes frequently overlook rest for increased training load, intensity, and volume.

Beyond sleep, nutrition, and hydration, the application of temperature-based modalities to accelerate recovery and alleviate the adverse symptoms associated with training and competition has become increasingly studied.[2,3] Water immersion is an increasingly popular recovery protocol many athletes utilize, but is it effective?

Using cold, hot, or contrast immersion also applies additional physiological stresses during the post-exercise recovery, which could be relevant for enhancing training adaptations[4]. However, the optimal water immersion protocols to assist athletic recovery remain unclear.

In the world of sports, where tiny margins make a big difference, anything that can return an athlete to training and competition quicker or a more recovered state is worth investigating. This article will assess the benefits, strategies, and drawbacks of cold, heat, and contrast immersion.

Louis Simmons said, "everything works. But nothing works forever." Varying recovery techniques may be as crucial to keeping an athlete's body functioning at peak level as varying their workouts.

Hydrotherapy has been used since ancient times to balance the body and mind. The Greek sage Hippocrates said water therapy "allays lassitude" (physical or mental weakness). Hydrotherapy takes advantage of the natural body reaction to exposure to cold and heat to make the body stronger.

Cold Water Immersion

Cold water immersion therapy, sometimes called cold plunge therapy, is a version of cryotherapy where athletes submerge themselves in chilly water, usually < 20 C, up to the chest for around 10-15 minutes. Taking this post-exercise plunge in ice baths is becoming a common practice among many athletes, especially in social media posts among elite athletes, and was even recently featured on Shark Tank.

We have all used the age-old RICE protocol using ice as standard injury treatment. The use of cold therapy is based on the application that cold reduces the perception of pain, speed of nerve conduction, and blood flow to working muscles, limiting the process of inflammation, and swelling to injured tissues.

The inflammation that accompanies exercise, in the right amount, can be beneficial. Training, or injury, induces muscle and tissue damage which activates a series of cellular mechanisms to promote adaptations to training. One process is inflammatory cells, macrophages, rushing to injured tissue to start the healing process. This causes the release of insulin-like growth factor (IGF-1), a potent anabolic hormone critical to the recovery and reconstruction of damaged tissue.

By blocking inflammation with cold immersion, the adaptive mechanisms would be prevented or slowed since cold delays healing by inhibiting the body from releasing

IGF-1. With this information, cold immersion might not be beneficial in pre-season when the goal is to induce adaptations and build muscle mass, which requires a large amount of inflammation.

Recent studies have shown applying cold partly reduces the adaptation to training.[5] Another found athletes who used cold immersion had three times lower gain in muscle mass than when the athletes recovered with the active recovery. Those who took active recovery gained almost double the strength of the group that recovered by cold immersion. These results showed that cold reduces the anabolic and myogenic response, i.e., minimizes the adaption processes for the muscle fibers.[6]

Sitting in cold water also causes blood vessels to constrict, preventing quality blood flow to muscles damaged and fatigued by exercise and thus transporting inflammatory agents, nutrients ingested, and cytokines to the damaged muscles. Then when you get out, the blood vessels dilate, flushing the circulatory system of metabolic wastes produced by the body after a workout.

There is evidence to support the effectiveness of cold application after exercise in reducing the perception of muscle pain and levels of creatinine kinase, a muscle damage marker in the blood. A study found a trend in improved muscle function recovery, concluding cold immersion may be an efficient strategy for alleviating fatigue and muscle pain in the short term. The cold immersion following exercise may be advisable when the objective is to avoid muscle pain and mitigate performance loss without affecting the adaptations produced from that session.[7,8]

While you may think cold immersion is not the best option for athletes, cold therapy has many positives. Cold immersion induces adiponectin, a hormone from adipose tissue, that serves as a potent anti-inflammatory by inducing the production of IL-10, an anti-inflammatory cytokine. Adiponectin also suppresses pro-inflammatory cytokine, TNF alpha, production. It also increases the muscle uptake of glucose, causing a reduction in blood sugar.[9]

Exposure to cold causes an increase in the number and activity of natural killer cells and IL-6, which strengthens the integrity of the immune system. Using cold therapy at the first signs of cold symptoms might help fight more effectively and starts a process where the body destroys some of its cells and strengthens the immune system. Cold therapy might be beneficial when traveling, long hours of training, or in high-stress times when immune health is usually depressed.

The vagus nerve, which connects the brain with all vital organs, plays a role in mental health and stress-related conditions. Exposure to cold water calms the vagus nerve, which turns off the sympathetic state, known as the fight or flight response. Research has found that exposure to cold water, even slight amounts on the face, can activate the vagus nerve, reducing breathing and heart rates and flipping the brain into parasympathetic mode, known as the rest and digest state. Getting your body into a parasympathetic state to heal and recover is critical for athletes, as training/competition is a sympathetic state.[10]

Heat Immersion

Heat application is mainly thought of in the rehabilitation setting, and its impact on post-exercise recovery and performance is now being investigated more in-depth. Thermotherapy, i.e., heat, is gaining popularity, again, from a physiological and psychological perspective of recovery.

Heat increases tissue temperature, local blood flow, and muscle elasticity. Heat also causes local vasodilation and reduces muscle spasms. The increased blood flow allows for an increased supply of oxygen, antibodies, and the ability to clear metabolites, such as lactic acid.

The primary rationale behind heat immersion is affecting heat shock proteins (HSP). HSP protect cells against stress and is often secreted during and affects physical exercise. For many people, HSP has gone into a sleep mood. Specific HSP play a role in muscle repair by recruiting cells involved in the inflammatory response and regeneration process. HSP also help prevent the breakdown of proteins, increase growth hormone release, and improve insulin sensitivity.[11,12]

Like exercise, heat induces muscle hypertrophy, a win-win situation for muscle building. Heat acclimatization, repeatedly exposing the body to a hot environment, can improve performance and heat tolerance and may provide a potent stimulus to enhance exercise performance in cool or temperate conditions while also reducing the amount of protein breakdown.[13,14] Intermittent heat exposure elicits a protective response to stress; heat immersion can be uncomfortable as you deliberately apply stress to the body. Heat can also drive training adaptations for upcoming events.

Exposure to heat can stimulate the same adaptations and be used to mimic the regenerative effects of exercise at lower physical costs. Adaptations happen as exposure to heat produces HSP that pre-conditions the cells, so subsequent stressors do not have the same impact as the initial event and can help 'train" the internal environment.[15]

Basking in a warm post-workout environment also increases blood flow to the skeletal muscle, keeping them supplied with glucose, fatty acids, and oxygen while removing by-products of the metabolic process. One study showed twice weekly 30 min sauna sessions for three weeks after training increased participants' run to exhaustion by 32%, but also a 7% increase in plasma volume and a 3.5% increase in the number of RBCs, meaning more oxygen supply.[16]

Recent studies are showing the application of heat (>36C) may be more effective than cold in improving post-exercise recovery, mitigating performance loss, accelerating re-synthesis of glycogen, and increasing the adaptation produced with training, especially those related to resistance (i.e., enhanced mitochondrial function).[17, 18]

Contrast Immersion

What about combining heat and cold? Warm spas with a cold plunge and hot-cold baths/showers are common contrast therapies becoming popular with athletes. Contrast therapy is believed to speed recovery by increasing the peripheral circulation by "pumping" the muscle/lymph, to remove metabolic water and stimulate the central nervous system. Further research shows that contrast hot-cold increases lactate clearance, reduces post-exercise edema, and enhances blood flow to the fatigue muscles. Additionally, contrast therapy slows down the metabolic rate and revitalizes or energizes the psychological state.

There are fewer studies and information on contrast for recovery, often due to the availability of both forms of immersion and/or the wide variation in types of contrast used. The commonly practiced ratio of warm to cold bath duration for injury treatment is 3:1 or 4:1, with hot ranging from 37-43 C alternating with cold baths ranging from 12-15 C, with a duration of usually 20-30 minutes and finishing on cold to encourage vasoconstriction, for injuries.[19]

While mild and probably positive, contrast baths maybe not be a substitute for longer-term exposure to heat or cold. Contrast offer comfort which makes them a consistent choice for low to moderate intensity and volume training sessions for athletes without a heavy training load, such as two-a-day session.

One study showed that lactate levels recovered equally fast using the contrast water immersion or the active recovery protocol. However, the lactate recovery following passive rest was significantly slower.[20]

The exact protocol for each athlete's training cycle is different. There is also a lack of consensus and scientific research establishing what is more critical: recovering to ensure subsequent training sessions are of the highest quality and intensity or avoiding any dampening of the training stimulus. Failing to recover optimally might lower the quality and intensity of later training sessions, reducing the intended adaptations. One day's failure to recover might negate the adaptive signals that would otherwise result from subsequent days and sessions.

When choosing a recovery program for an athlete, many co-variables might influence the recovery protocol decision. Variables that should be considered for each individual's recovery plan include competitive schedule, training duration/intensity, type of training (resistance vs. endurance), athlete goals, gender, the proximity of the next session, training cycles, budget, availability of recovery therapies, athlete preference, outside commitments/time constraints, and environmental temperatures.

Training and competition create an overload of stress on the body, producing fatigue followed by improved performance. Depending on the nature of the activity, nutritional, physiological, neurological, and psychological components are stressed in different ways that result in fatigue. Athletes need a multi-pronged recovery plan based on stressed systems, including rehydration, carbohydrate intake, active recovery, massage, visualization, mediation, hydrotherapy, passive rest, and water immersion. A complete recovery plan with various tools in the athlete's toolbox gives better responses than isolated recovery techniques.

Application Cold Water Immersion

One aspect of cold immersion not covered in-depth but noted in antidotal stories from many athletes, including myself who have used cold immersion for most of my volleyball career, is the mental training that cold water immersion offers. Here are two situations of how athletes approached cold water immersion to improve mental strength.

Many athletes that use cold water immersion soon learn that it's more than just recovery, but a way to clear your mind, strengthen your mindset, and harness breathwork to control the response of

your nervous system. It's training differently without adding additional physical stress to your body.

One collegiate football kicker uses cold therapy to test his mind, visualizing punting and kicking field goals when in the water bath, using his meditation and visualization skills. Cold water immersion shocks our body into a sympathetic response. We experience shivering, increased heart rate, rapid breathing, and release of norepinephrine. He capitalizes on this opportunity to learn to calm his breathing while his body is under stress. This allows him to simulate the stressful situation of a big game time kick repeatedly on an almost daily basis so he can work on strengthening his mind, calming his body, and training his breath.

For me, the anticipation of the ice bath was worse than the bath itself, sitting on the edge of the tank trying to convince myself to jump in 3, 2, 1.5, 1, eek! The cold therapy turned into a workout of mental toughness to conquer fear, anxiety, or stressful situation. I learned to approach it without hesitation or anticipation but with confidence and knowledge of "I can, and I will survive it." This was a turning point, approaching cold water immersion as a challenge, like a stressful situation in life or sport, knowing I can conquer it and come out stronger. It might feel uncomfortable for a moment, but "I can do it."

Tips to maximize cold water immersion to build mental resilience and stress inoculation training:

1. Control your breath – when you first enter, you will want to breathe quickly and shallow. Focus on controlling your breath; do so by visualizing you are breathing through a straw. You can even use a physical straw to practice. Control your breath and slow it down. You can also add a breath hold to help stop the erratic breathing.
2. Calm and soothe your body and mind – Once breathing is under control, work to a 1:2 inhale-to-exhale rate. For example, I like inhaling a count of 4, holding briefly, exhale for a count of 8.

Control your breath, and your mind in a situation will allow you to better train yourself to regulate your nervous system.

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Hydration for Athletes

By Melissa De Brito, PharmD, AFMC

AUTHOR BIO:

Dr. Melissa De Brito, is a pharmacist, functional medicine health consultant, and health coach. Dr. Melissa received her Doctor of Pharmacy degree from the University of Tennessee College of Pharmacy in 2011. She has completed pharmacy residency training and has worked as a clinical pharmacist in the hospital setting. Dr. Melissa has additional certification training in functional medicine, culinary nutrition, group fitness, and restorative wellness with ongoing lifelong education in these areas as well. She has turned her passion for functional and lifestyle medicine to educating and empowering others to take control of their health by unlocking the body's healing potential and addressing the root cause of their underlying health challenges. Melissa also knows what it's like to be a high-level athlete, having played D1 soccer and running in half marathons. She now coaches soccer in her area as well.

Euhydration, Dehydration and Hydration

Maintaining euhydration, the state where the body has an adequate volume of water to meet physiological demands and to stay within its optimal homeostatic range, is essential in functioning properly. The human body is comprised of approximately 50-70% water. Almost 2/3 of total body water is found within the intracellular fluid while approximately 1/3 is within the extracellular fluid (ECF). Water is one of the most essential nutrients of life. It works as a medium for biochemical reactions and processes, transports nutrients, oxygen, and waste material, assists in thermoregulation, and is critical for cellular exchanges.

Dehydration, the process of incurring a fluid deficit by losing body water and moving from a state of euhydration to hypohydration, can ensue when an athlete's sweat loss exceeds fluid intake. Dehydration of 2-3% or more of body weight can impair coordination, cognitive tasks, and physiologic function while increasing risk of heat-related illness. Unfortunately, this level of dehydration is common and can occur within one hour of exercise, or more rapidly if the athlete is dehydrated prior to the start of a training session. Staying hydrated is important for humans at all activity levels, but it is especially important for athletes during vigorous exercise. Hydration is the process of adding adequate amounts of fluid to bodily tissues, and optimal hydration requires a balance of fluids and electrolytes. Maintaining hydration in the athlete is dependent on many factors, and it must also be combined with avoiding excessive fluid intake as this can result in overhydration potentially leading to hyponatremia.

Factors Contributing to Hydration

Fluid intake recommendations for athletes have evolved, and the current consensus recommends good hydration practices include beginning training in a state of euhydration, preventing excessive hypohydration while training, and replacing remaining fluid losses following training and prior to the next training session. It is acknowledged that fluid needs rely on many factors and should be individualized to the athlete. These factors include environmental conditions such as ambient temperature, heat index, humidity, clothing and equipment, altitude, and air flow; intrinsic factors such as sex-specific differences, age, body size, and sweat rate; and sport-specific factors. Furthermore, biochemical changes occur during exercise that can alter thirst sensation, so drinking to thirst only is not always optimal. Consideration of these factors can be used as a general guideline to help strategize a hydration plan for the athlete with practical strategies to assess and tailor hydration.

Assess Hydration Status

Hydration status should be assessed and monitored, and there are a variety of ways to monitor the body's hydration status with varying degrees of accuracy, difficulty, expense, and practicality. The two most precise methods are also the most impractical, expensive, and difficult to obtain for day-to-day use by athletes and are best suited for research studies. One of these methods includes a measurement of total body water and plasma osmolality from a radioactive isotope dilution using deuterium oxide, and the second method is through a

blood sample that measures plasma osmolality, the number of particles of solute per liter of plasma. The plasma osmolality measurement associated with euhydration is between 275 and 295 milliosmoles per kilogram, and dehydration is a plasma osmolality of >300 milliosmoles per kilogram.

Daily monitoring of hydration status for the athlete should be practical, easy to perform and understand, which is why a practical means of measuring dehydration in the athlete is using a combination of first morning urine color, body weight, and thirst. In the morning, the athlete can evaluate whether body weight is noticeably lower than the previous morning (ideally maintaining day-to-day body weight within 1%), the darkness or lightness of urine color with darkened color suggesting hypohydration, and if there is thirst, craving of fluids or dry mouth. The presence of two of these conditions suggests hypohydration is likely present, and the presence of all three conditions suggests it is very likely that hypohydration is present. Limitations of this practical hydration assessment method include that urine color can be affected by diet, dietary supplements, and medications, and checking body weight every day might be detrimental if an athlete struggles with an eating disorder or anxiety related to degree of body fatness.

Hydration strategies can be pursued based on the above-mentioned factors and determinants of hydration status. Evaluation questions to consider when formulating a hydration plan for the athlete include:

1) Is the athlete euhydrated?
2) What are the athlete's goals prior to exercise?
3) What are the athlete's goals during exercise?
4) What are the athlete's goals after exercise?

Additional considerations for developing a hydration plan include increasing the availability of fluids, establishing breaks based upon environmental conditions, making fluid readily available for athletes, maximizing opportunities for rehydration, identifying athletes with high sweat rates or other factors that limit optimal hydration, identifying athletes who have altered thirst drive compared to their fluid loss, counseling and monitoring athletes on proper hydration, counseling athletes on the health and performance risks of dehydration as well as overhydration.

Indexed of Hydration Status			
Condition	% Body weight change	Urine Color	Urine Specific Gravity (USG)
Well hydrated	+1 to -1	1 or 2	<1.010
Minimal Dehydration	-1 to -3	3 or 4	1.010 to 1.020
Significant Dehydration	-3 to -5	5 or 6	1.021 to 1.030
Serious Dehydration	> 5	> 6	> 1.030

Composition of Hydration Mixes for Athletes

The composition of the fluid that an athlete consumes to maintain hydration is important. Approximately 95% of all fluid absorption occurs in the small intestines, and it works to keep water and sodium in balance so that blood plasma remains within the normal osmolality of 275 and 295 milliosmoles per kilogram. Ideally, the fluid being consumed should be a lower osmolality than the blood so that the intestinal walls allow it to pass into the bloodstream. If the fluid consumed is overly concentrated compared to the blood plasma osmolality, then the intestinal cells will pull water from the vascular spaces of the body to dilute the higher osmolality within the intestines. This potentially adds to dehydration and can trigger gastrointestinal distress from excess fluid sitting in the intestines due to an osmotic effect.

Optimal hydration requires fluid that contains co-transporters working molecularly to carry fluid across the intestinal cells and into the vascular water spaces of the body. Sodium works to maintain fluid in the plasma for evaporative cooling and sweating, enhances fluid retention, increases the body's natural thirst sensation, and enhances glucose and water absorption from the intestinal walls and into the bloodstream for cellular hydration. Glucose and sodium work together with the transport mechanisms in the intestines, and without a small amount of glucose, the constant flow of sodium and water into the bloodstream can slow down. This is also why consistently drinking plain water is not

satisfactory for optimal hydration, because plain water does not contain the drivers to get the fluid into the cells of the vascular spaces. Plain water can also signal a volume response in which the body urinates and flushes out more water and electrolytes than what is being absorbed. The inclusion of sodium in a hydration sports drink during training is paramount, while the inclusion of potassium, magnesium, and calcium is not as critical if the athlete is consuming these electrolytes through nutrient-dense foods in their diet. Sodium-based electrolyte drinks are ideal, and addition of potassium and magnesium in a hydration sports drink can be a personal preference or included when the exercise intensity is high, or the duration of exercise is prolonged.

Historically, many of the available sports drinks have contained a 5 to 8% carbohydrate solution. This can be too concentrated for some athletes causing a water influx into the intestines, as the osmolality of a higher carbohydrate solution can be higher than normal blood osmolality. Certainly, concentrations greater than 8% slow the rate of fluid absorption and coupled with intense exercise will have a decreased rate of gastric emptying. A fluid solution of glucose and/or sucrose at a 1.5 to 4% carbohydrate concentration combined with sodium works with the rules of osmolality allowing for faster emptying out of the stomach and greater fluid absorption from the small intestines into the cells. The optimal hydration strategy for the athlete is to show up hydrated prior to training by pre-hydrating, take in enough sodium to work with the physiological demands under exercise stress conditions, and then appropriately rehydrate after training.

Dr. Melissa De Brito competing in a soccer tournament

An example of the fluid composition to recommend the athlete consume could be a homemade functional hydration mix containing per 16 ounces of filtered water 1 teaspoon of pure maple syrup with 1/16th to 1/8th of a teaspoon of quality salt. If a pre-mixed product is preferred, it is important to consider the goals of the athlete, and if they are targeting hydration prior to training, during training, or following training, as well as the intensity and duration of exercise. Many hydration drink mixes are available on the market that consider electrolyte ratio (sodium, potassium, magnesium, calcium) and carbohydrate content. Some commercial sports hydration mixes market for hyperhydration (indicating a pre-training mix) and sport and endurance (indicating use for during training). Other characteristics to consider when choosing a hydration product are products that contain no coloring, artificial ingredients, or sugar substitutes indicating a product with clean ingredients. Sugar substitutes such as sorbitol, mannitol, and xylitol are sometimes used in "lighter" or low-calorie sports beverages, but it is important to understand that some of these sugar substitutes cause gastrointestinal distress to the athlete and as mentioned, a small amount of glucose is ideal to work with sodium to shepherd fluid across the intestinal wall and into the cells. Some natural sweeteners such as stevia can be well tolerated by some athletes but can cause gastrointestinal issues for others.

Fluid Intake Prior to Training and Performance

Fluid intake before training and performance depends on the athlete's goals and tolerances. Typically, the goal is to be fully hydrated prior to training and, if not fully hydrated, rehydrating to the greatest extent possible while avoiding gastrointestinal upset. Many athletes become chronically dehydrated when they perform repeated exercise trainings either on the same day or on consecutive days. A hypohydrated athlete will have compromised physiologic mechanisms when they begin to exercise. For endurance athletes, one of the single most effective strategies is pre-hydrating starting the one to two days before endurance training or competition with sodium-rich fluids such as organic bone broth or a sports nutrition sodium-based hyperhydration drink mix. Throughout the day on the day of training, eating watery fruits and vegetables, drinking herbal tea, mineralized water, or low carbohydrate electrolyte drinks can help athletes stay hydrated. One study by Sawka et al. recommends pre-training fluid consumption begins at least 4 hours prior to training, and if the athlete has already rehydrated from the previous day's exercise, then the fluid intake should be slow. The amount of fluid intake will depend on the individual, but a general rule of thumb is to have the athlete consume ~5 to 7 mL/kg at least 4 hours prior to training. For example, a 50 kg athlete could start with a goal of consuming 250-350 mL of fluid before exercise begins. Additionally, there are studies showing that fluid consumption in the 90 to 105 minutes leading up to a high intensity and longer duration training session with a high-sodium solution can reduce feelings of fatigue, reduce the rise in core body temperature, reduce average heart rate, and increase exercise duration. These studies looked at adding high amounts of sodium of 2.3 to 4.3 grams in 22 to 33.8 ounces of water consumed prior to exercise, but further research needs to be performed to evaluate athletic performance and safety with this amount of additional sodium.

Fluid Intake During Training and Performance

During training, many athletes benefit from fluid consumption during exercise, and typical goals include maintaining power to the end of the session, preventing excess dehydration (>2% body water loss) while acclimating to mild dehydration, avoiding overconsumption of water and hyponatremia, replacing sodium losses only to meet the physiologic demands under exercise conditions, consuming some glucose, and avoiding gastrointestinal upset. Appropriate hydration during training sessions will positively influence cardiovascular function, thermoregulation, muscle function, fluid volume status, and exercise performance. One of the reasons why hypohydration is difficult to completely avoid while exercising is because of the physiological inability to empty water from the stomach and absorb it into the blood as fast as it is being lost. While the maximum rate of gastric emptying and fluid uptake in adults is approximately 1 liter per hour, water may be lost in sweat at rates twice that amount when heavy sweating takes place. However, given the small contribution of water from metabolic processes, athletes may not need to exactly match fluid intake with sweat loss to maintain water balance.

In the past, recommended guidelines for fluid replacement during exercise was to consume approximately 150 to 350 mL of fluid at 15- to 20-minute intervals beginning at the onset of exercise. However, current guidelines have evolved and organizations such as The American College of Sports Medicine (ACSM) now recommend a customized plan that considers the factors discussed earlier. ACSM makes a generalized recommendation of consuming 0.4 to 0.8 liter of fluid per hour as a starting point for endurance athletes during exercise, although some athletes may need less or more. For lower intensity training or sessions shorter than 90 minutes, a functional hydration drink mix that contains water, a low-carbohydrate glucose and/or sucrose solution, and quality salt might be sufficient. An example of this type of functional hydration mix for lower intensity or shorter duration training would be adding 1/16th of a teaspoon of quality salt and 1 teaspoon of pure maple syrup to 16 ounces of filtered water, yielding approximately 145 mg of sodium and 4 grams of carbohydrate, which is ~1.5% solution, and on hotter days adding 1/8th of a teaspoon of quality salt can be added per 16 ounces. Training sessions lasting longer than 90 minutes or in the heat might require a hydration beverage that contains 3-6% carbohydrate from glucose and/or sucrose, 150 to 180 mg sodium, and 50 to 100 mg potassium per 8 ounces of water, although there are some studies that reference carbohydrate solution concentrations up to 8% do not adversely affect the rate of fluid absorption.

Fluid Intake After Training and Performance

Replenishment after training and performance should involve rehydrating and restoring lost body water, replacing sodium and other

electrolytes lost, consuming adequate protein to build and repair muscles, consuming enough carbohydrate to restore muscle glycogen stores that aid in recovery, and avoiding gastrointestinal upset. Slowly rehydrating over the course of 2 to 3 hours is best to avoid the pressure response of flushing out more water and electrolytes than the athlete can absorb. A few options for rehydration include a protein and nutrient-dense carbohydrate smoothie or through whole foods such as watery fruits and vegetables, as well as more of a functional hydration mix containing sodium, other electrolytes (potassium, magnesium, calcium), and a low amount of carbohydrates.

Risk of Hyponatremia

Hyponatremia, although a rare occurrence in shorter athletic events, is a serious medical risk that may occur in endurance athletes who have prolonged exercise extending beyond 2 or 3 hours. Hyponatremia occurs when the plasma sodium concentration falls below 135 mmol/L, and exercise-associated hyponatremia is often characterized by a rapid drop to 130 mmol/L or below. Because of the importance of sodium in maintaining osmotic fluid balance between water compartments, low sodium concentrations in the ECF stimulate the movement of water via osmosis from the plasma ECF into the intracellular space causing the cells to swell. When nerve cells swell too much they begin to malfunction resulting in dizziness, confusion, seizure, coma, and possibly death. To prevent hyponatremia in the athlete, it is important to replace sodium and prevent fluid overload or overdrinking. Hydrating excessively with plain water or low-solute beverages can make the athlete susceptible to hyponatremia. It has been recommended that a hydration beverage contain approximately 500 to 700 mg of sodium per liter of fluid and that fluid intake does not exceed sweat losses to prevent exercise-associated hyponatremia.

Hydration Strategy Testing

A practical solution for determining if an athlete's current hydration plan is maintaining hydration is to test his or her current hydration strategy. Hydration status can be assessed by measuring body weight before and after exercise training sessions to assess approximately how much fluid was lost, along with monitoring urine color, urine specific gravity (USG), or urine volume. Using urinalysis strips with specific gravity can help determine if the current hydration strategy is working in the athlete's favor. A USG reading of less than 1.010 reflects a well-hydrated status, while a reading of more than 1.020 indicates dehydration. Using this strategy, the athlete would first test his or her current baseline hydration strategy and a specific exercise session. Measure body weight and urine specific gravity before and after the specific exercise session. If the exercise session is longer than 2 hours, then consider also testing the USG in the middle of the session. Assess if hydration was maintained with the current hydration strategy considering before, during, and after hydration. One week later, add a functional hydration drink using electrolyte and carbohydrate ratios that the athlete desires to test (e.g., higher electrolyte and lower carbohydrate solution). Then, perform the same testing of body weight and USG before and after the same type of exercise session, ideally the same time and day of the week, if possible. Compare the USG from baseline and the follow up test one week later. The athlete can then reevaluate regularly to determine if any changes need to be made to the hydration strategy.

Hydration status can be assessed by measuring body weight before and after exercise training sessions to assess approximately how much fluid was lost, along with monitoring urine color, urine specific gravity (USG), or urine volume.

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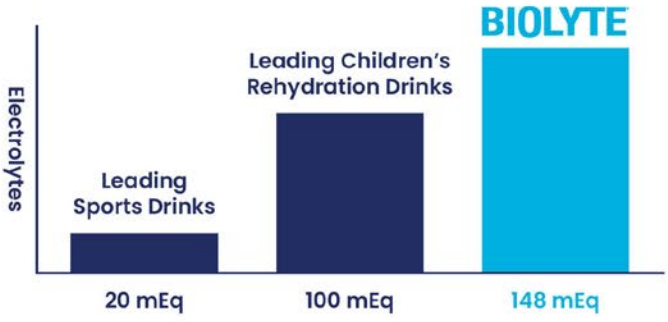

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Can Beetroot Juice Benefit Exercise Recovery?

By Dr. Matthew Liaw, Pharm.D.

AUTHOR BIO:

Matthew Liaw is a pharmacist with ten years of service to Navajo people at Crownpoint Healthcare. He is also an amateur distance runner specializing in the 10k, half-marathon, and marathon. As a pharmacist, he has led a medication error subcommittee, run a pain management clinic, and led an antimicrobial stewardship program. The runner in him is a scientist who enjoys repeating physiology trials to see how valid they are for his training. Some of his favorite moments at the UNM physiology lab include testing how shoes affect running economy, testing the impact of an extended interval block, and comparing methods of body fat testing. His dream is to bring his expertise in pharmacy and passion for running together and become a sports pharmacist.

A Introduction to Beetroot Juice

Over the past two decades, there has been much interest in the performance enhancing effects of beetroot juice. Work in average people had discovered nitrates in the form of beet concentrate improved the oxygen cost of exercise (Bailey et al., 2009). However, there were questions on whether beetroot juice benefits conditioned athletes. Some studies showed a lack of benefit in performance in competitive athletes (Hurst et al, 2020). Others suggested an increased dose taken chronically can still benefit well-trained athletes (Rokkedal-Lausch et al., 2018). In addition, it has been suggested supplementation enhances contractile properties of skeletal muscle (Gaider, Folland, 2014). Nitrate is inert but about 5 to 7% is converted by bacteria orally into nitrites. The nitrites enter circulation and are reduced to nitric oxide which exhibit a vasodilatory effect. This vasodilatory effect increases blood flow and theoretically enhances the delivery of oxygen to metabolically active tissues. In the pharmaceutical world, its use is commonly seen to prevent chest pain in those with coronary artery disease or as a rescue medication in patients with symptoms of a heart attack. Phosphodiesterase type 5 inhibitors like sildenafil also work on the same pathway by reducing cGMP breakdown thereby prolonging vasodilation (Gudmundsdóttir et al., 2005). These effects have garnered interest in studying the benefits of a dietary nitrate source in athletes and encouraged athletes to look to beet juice as a performance enhancer.

In addition to performance benefits, there was interest in the possible benefits of beets in recovery from exercise. Although nitrate is the primary molecule of interest in beet supplementation, beets also provide antioxidants like phenolic acids, flavonoids, carotenoids, and betalains (Clifford et al., 2016). In addition, beetroot juice provides significant amounts of carbohydrate which is an important macronutrient recovery from endurance exercise (Jeukendrup, Gleeson. 2018). This creates challenges when studying where the potential recovery benefits of beetroot juice come from.

Recovery Studies

Early attempts at studying beetroot juice benefits in recovery used beetroot juice compared to an isocaloric placebo (Clifford et al., 2016). Eccentric exercises in the form of 100 drop jumps were performed in thirty male subjects at Northumbria University. After 48 and 72 hours, the subjects performed countermovement jumps (CMJ) to measure lower body power and had inflammatory markers like creatine kinase (CK), interleukin-6, interleukin-8, and tumor necrosis factor-ś measured. While there were no significant differences in inflammatory markers, the subjects who took beetroot juice were able to perform higher CMJ than the placebo. This suggested there may be a functional recovery or neuromuscular protective effect with beetroot juice even though there are no benefits in inflammation.

While eccentric exercises use explosive power, an event like the marathon can also increase inflammatory markers, cause muscle damage, and induce muscle soreness for days after the event. Similar to the first study, the team at Northumbria University studied the impact of beetroot juice supplementation on function and inflammatory markers in marathon runners (Clifford et al., 2016). To reduce the effects of other recovery methods, cold water immersion, compression, foam rolling, NSAIDS and antioxidants were prohibited. The results showed no significant difference between use of a placebo and beetroot juice for the purpose of recovery after

a marathon. One characteristic that stood out was that the beetroot subjects had almost twice the number of years of experience in the sport compared to the placebo. Weekly training distance was similar. However, the predicted finish time was more accurate in the beetroot athletes than the placebo. This opens up the question of whether or not the additional years of experience allowed some athletes to further develop anti inflammatory and vasodilatory responses to exercise more than their peers.

Because of the many compounds in beet juice, there was a debate about whether the antioxidants or the nitrates were the most important molecule to exercise recovery. The same team from the previous study compared beetroot juice to a nitrate only drink and a placebo drink in recovery from eccentric exercise (Clifford et al., 2017). Interestingly, the groups underwent a plyometric routine to induce muscle damage but details about what types of plyometrics were missing which makes comparison to their 2016 study difficult. This time no significant differences in function and inflammatory markers. However, beetroot juice improved the pressure-pain threshold 72 hours after the exercise compared to placebo and nitrate drinks. This led the team to conclude that the phytonutrients in beetroot juice played a larger role in analgesic effects after exercise over nitrates.

A final study performed by the University of California Davis Sports Medicine Program attempted to find out whether betalains can improve recovery in triathletes (Montenegro et al., 2016). They depleted most sugars and nitrates from their supplement and left the antioxidant compounds. This has the benefit of studying the antioxidants without nitrates being a confounder. Five sessions were held. The first was a practice 10k time trial cycling bout. The athletes then take the batalain supplement for 6 days before performing a 10k time trial on day 7. The following day (day 8) the athletes perform a 5k time trial to measure their function. These time trials were repeated on days 14 and 15. The results showed less of an increase in creatine kinase in the betalain group and faster 5k time trials. This suggested an improvement in both reduction in inflammation and functional recovery.

Final Thoughts

Studies on the subject of beetroot juice and recovery are still in its infancy. While there appears to be benefits to functional and inflammatory recovery, the studies contradict each other and warrant further study. Although considered a low risk supplement, beetroot juice does come with some side effects. From personal experience and other users, red urine, red stool and stomach upset were common adverse effects. For a pharmacist or healthcare professional advising an athlete, care should be given to warn patients of these effects as they can be alarming for first time users. These effects are not life threatening, but it is possible they can mask other issues. Patients undergoing a colonoscopy should avoid this supplement as the red or pink stools may be mistaken for or mask hematochezia. Because the nitrates in beetroot juice are similar in action to nitrates used in medicine, there may be an interaction with PDE-5 inhibitors similar to the significant lowering of blood pressure leading to fatal hypotension and fainting. However, there have been no cases of such an interaction reported to date. It is possible that the concentrations obtained by diet are too low to reduce blood pressure to fatal levels. Overall, the evidence for using beetroot juice is stronger as a possible performance enhancer in endurance sports over its use as a recovery agent.

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Quick Reference Table

Micronutrients (Vitamins)

Vitamins			
Chemical name	Vitamins	Function	RDA
Choline		Responsible for creation of acetylcholine (aid with muscle function)	Men/Women: 425mg/day
Thiamin	B1 (water-soluble)	Energy transformation (coenzyme role) Necessary for metabolism of carbs and amino acids Membrane and nerve conduction	Men: 1.2mg/day Women: 1.1mg/day
Riboflavin	B2 (water-soluble)	Energy production (creates FAD+) Vitamin B6 metabolism and choline breakdown	Men: 1.3mg/day Women: 1.1mg/day
Niacin	B3 (water-soluble)	Used to create NAD+ Converts food into glucose Helps create fatty acids and cholesterol	Men: 16mg/day Women: 14mg/day
Pantothenic acid	B5 (water-soluble)	Creation of coenzyme A	Men: 1.3mg/day Women: 1.2mg/day
Pyridoxal Phosphate	B6 (water-soluble)	Needed for normal brain function Coenzyme for transamination and deamination (Protein metabolism)	Men: 1.3mg/day Women: 1.2mg/day
Biotin	B7 (water-soluble)	Essential for breakdown of amino acids and fatty acids Essential for breakdown of leucine	Men/Women: 300mcg/day
Folate	B9 (water-soluble)	Amino acid metabolism Helps with the development of red blood cells Purine and pyrimidine synthesis	Men/Women: 400micrograms/day Pregnant: 800micrograms/day
Cobalamin	B12 (water-soluble)	Helps maintain healthy nerve cells Helps in production of DNA and RNA Production of succinyl-COA in the breakdown of essential amino acids	Men/Women: 2.4mcg/day
Ascorbic Acid	C (water-soluble)	'Cement' for connective tissues Anti-oxidant Wound healing Iron absorption Co-factor in neurotransmitter creation	Men: 90mg/day Women: 75mg/day
Retinol/Retinal/Retinoic acid	A (fat-soluble)	Vision Maintenance of cornea, mucous membrane and skin Bone and tooth growth	Men: 900micrograms/day RAE Women: 700micrograms/day RAE
Cholecalciferol	D (fat-soluble)	Aids in calcium & phosphorous absorption, bone building Increases troponin C in muscles	Men/Women: 10-20 mcg/day
Alpha-Tocopherol	E (fat-soluble)	Anti-oxidant	Men/Women: 15mg/day
Phylloquinone	K (fat-soluble)	Aids in calcium binding to protein	Men: 120micrograms/day Women: 90micrograms/day

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