First Aid for Muscle Cramps, Strains, and Sprains

MUSCLE CRAMPS

Muscle cramps can occur any time—during exertion or at rest. Sometimes they're caused by certain medications or dehydration.

- Have the victim stretch out the affected muscle to counteract the cramp.
- Massage the cramped muscle firmly but gently.
- Apply heat. (Use a heating pad or a hot water bottle wrapped in cloth.) Moist heat is more effective than dry heat. *Do not* apply direct heat to the skin.
- Get medical help if cramps persist.

MUSCLE STRAINS

- Muscle strains are commonly known as pulled muscles.
- Apply cold compresses at once. Reapply them for 20 minutes every 3 to 4 hours for the first 24 hours. (*Do not* apply ice directly to the skin.)
- If the strained muscle is in an arm or leg, elevate the limb to reduce swelling and bleeding within the muscle. Rest the pulled muscle for 24 hours.
- Get medical help if the victim is in great pain or if a body part is not working properly.

More on the Subject

If the muscle feels better after 24 hours, apply heat as often as possible for the next 3 to 4 days. *Do not* apply direct heat to the skin. If the problem has not improved in 24 hours, get medical help.

A strained muscle should not be used as long as it is painful. When it is no longer painful, the victim should return to full activity gradually. If the muscle starts to hurt again, reapply heat and slowly start activity.

SPRAINS

If the victim is severely injured or you suspect a broken bone, call for emergency services. Get medical help if the injured area is misshapen, if the victim is in great pain, if a body part is not working properly, or if there are signs that circulation beyond the injured area has been impaired.

Do not give the victim anything by mouth if you suspect severe injury.

Do not ignore persistent joint pain. A body part that hurts should not be used.

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- Remove any clothing or jewelry from around the joint.
- Apply cold compresses at once. Reapply them as often as possible (at least for 20 minutes every 3 to 4 hours) for the first 24 hours. (*Do not* apply ice directly to the skin.)
- Elevate the affected joint with pillows or clothing. Do not move the injured area for at least 24 hours.
- The victim's physician may recommend an over-the-counter anti-inflammatory medication (aspirin, ibuprofen) appropriate for the victim's general health.

NOTES:

Heat Therapy

WHEN CAN I USE HEAT THERAPY?

Heat therapy can be used in the repair stage of an injury. This is usually 48 hours after the initial injury, once the risk of internal bleeding is minimal. During repair, new tissue is formed. Heat helps build this tissue by increasing blood flow and cell metabolism.

WHEN SHOULD I NOT USE HEAT THERAPY?

Heat in any form should NOT be applied to an acute injury or where discoloration or swelling is present. Heat can produce an increase in internal bleeding and swelling. Heat should not be applied to a person who has trouble feeling heat. Generally, heat should not be used on infants or elderly persons.

WHAT IS HEAT THERAPY GOOD FOR?

Moist heat is good for muscles that are sore, tired, or overworked. Heat may be used to help relax tight muscles, preventing injury. For instance, runners may have tight upper thigh muscles because they have extended and locked their knees many times. If these muscles are allowed to remain tight, spasm can occur, accompanied by pain. The tightness can be reduced by applying heat and massaging the thigh muscles before running. Heat and massage also may help shinsplints.

Heat may be used to ease chronic pain such as that associated with arthritis. The use of heat relaxes the muscles, reduces stiffness, and makes using the affected body parts easier. The use of heat in patients with arthritis may permit them to reduce the dosage of pain-relieving drugs. Heat may be applied for 20 minutes every 2 to 4 hours as needed to relieve chronic pain.

GUIDELINES FOR USING DIFFERENT TYPES OF HEAT THERAPY

- **Hot water bottles** are frequently used to apply heat. Fill the bottle half full of hot water. Remove excess air in the bottle by pressing it above the water level with your hands. Removing this air permits the bottle to conform more readily to the body. Check the temperature of the bottle against the back of your hand or forearm to be sure it is not too hot. The bottle should not come into direct contact with the skin. A towel wrapped around the bottle will provide comfort and safety. After applying the heat, empty the hot water bottle and hang it upside down to dry. A hot water bottle is an effective means of applying heat. However, a disadvantage is that the water cools rapidly and must be changed frequently.
- **Hot tubs** or heated whirlpools can relax muscles and ease joint stiffness. The temperature of the water should be about 104°F (40°C). Higher water temperatures may produce a sensation of fever and/or drowsiness. Do not drink alcohol while using a hot tub.

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- **Electric heating pads and heat lamps** may also be used to apply heat treatments. Specific safeguards must be used with each. Heating pads have limited flexibility and can cause bums if a patient falls asleep while using one that is set at a high temperature. *Heating pads should always be used on top of the part of the body receiving the heat treatment.* Pins and other metallic fasteners should not be used to keep a heating pad in place. Heating pads should not be used without a cover, nor should they be folded sharply. Also, the pads should be stored in a cool, dark place when not in use. When a heat lamp is used, a patient must be alert for burns and, in extreme cases, heatstroke. A heat lamp should not be used to apply heat to skin that has no feeling or is numb, over skin that is covered by a rash, or over scar tissue. Children should never be allowed to use a heat lamp unattended.

NOTES:

Source: Adapted with permission of Ross Products Division, Abbott Laboratories, Columbus, OH 43216, from "Using Heat and Cold as Treatments,"

Cold Therapy

WHEN CAN I USE COLD THERAPY?

Cold therapy is used for all acute injuries to:

- Stop internal bleeding.
- Relieve pain.
- Reduce muscle spasms.
- Cool deep tissues.

Cold therapy is the ideal treatment for athletic injuries such as contusions, muscle pulls (strains), sprains, and fractures. The earlier the cold therapy is started, the better. Remember **RICE** as a guide to treating acute injury. **RICE** stands for **R**est the injury; apply **I**ce; apply **C**ompression (pressure); and **E**levate (raise) the injury.

WHAT ARE SOME SPECIFIC USES FOR COLD THERAPY?

Contusion

A contusion is a bruise without a break in the skin, usually caused by a hard blow to a muscle. The blow damages the muscle fibers and tears small blood vessels. The result is internal bleeding, swelling, and pain with movement. Contusions are common injuries in contact sports, such as football.

Ice should be applied immediately to a contusion and kept on for 15 minutes. Ice should not be applied longer than 20 minutes at a time. When the ice is removed, the bruise should be covered with a light foam pad and secured with an elastic bandage wrap. Cold therapy should be continued daily until the discoloration and swelling are gone. Exercises to regain full use of the injured area should be started as soon as the person is able.

Muscle Pull (Strain)

Muscle pulls or strains occur when the muscle is damaged by a contraction while it is under excessive strain. Examples are a runner in full stride making a sudden turn to avoid hitting an object or a person lifting an object that is beyond his or her muscles' capability. The muscle fibers stretch and tear, resulting in internal bleeding and swelling. Strains usually involve large muscle groups such as the quadriceps, hamstrings, and calf muscles.

Apply ice with pressure and elevate the limb. Activity can be resumed gradually after the pain and swelling have gone and full use of the limb has returned.

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Sprain

A sprain is an injury to the ligament of a joint. Some of the fibers of a supporting ligament have been torn apart. Complete tearing of a ligament is called a *laceration.* Sprains occur when a joint is forced beyond its normal range of motion. Small blood vessels are torn in the injury and internal bleeding occurs. Swelling is usually great. Ligaments have many nerve endings and the pain can be severe.

RICE (rest, ice, compression, and elevation) is the recommended treatment. Cold eases the pain and also helps restore motion. Persons with moderate or severe sprains of the leg should use crutches when walking. A person should ideally have normal strength and full use of the injured body part before returning to athletic competition or engaging in strenuous exercise.

Fracture

A fracture is a crack or break in a bone. If a fracture is suspected, a splint should be applied to the bone immediately, and ice should be used while the person is being transported to a health facility for professional care.

HOW DO I APPLY COLD THERAPY?

Because the fat that underlies the skin does not conduct cold readily, the application of cold for short periods will not cool the deeper tissues, only the skin. To be effective for tissues beneath the skin, cold should be applied by means of an ice bag or ice pack for at least 15 minutes. Cold should not be applied for longer than 20 minutes. Do not put ice directly on the skin for long periods.

The skin passes through four stages of sensation within 10 to 15 minutes. These sensations are, in order, cold, burning, aching, and numbness. Cold application should be stopped once the skin feels numb.

Ice can be placed in an ice bag or wrapped in a towel and applied to the site. Another option is to use chemical cold packs. Cold can also be applied by massaging the affected area with ice blocks held in the hand. Water frozen in a foam cup is an effective way to use this technique. Peel the top of the cup away, leaving the bottom to hold on to, and rub the ice directly on and around the injured area. Do not hold the ice in any one spot for more than 3 minutes because of the potential for frostbite.

First Aid for Dislocations and Broken Bones

If a joint is overstressed, the bones that meet at that joint may get disconnected, or *dislocated.* When this happens, there's usually a torn joint capsule and torn ligaments, and often nerve injury.

If more pressure is put on a bone than it can stand, it will fracture (split or break). Open fractures (in which bone pierces the skin) can easily become infected.

If an infant or toddler does not start to use an injured arm or leg within hours of an accident, or if he or she continues to cry when the injured area is touched, assume the child has a broken bone and get medical help.

It's hard to tell a dislocated bone from a broken bone. Both are emergencies. The general first-aid steps are the same for both:

- If you suspect that the victim has a dislocation or a broken bone, and there is severe bleeding, call for emergency medical services.
- If you cannot completely immobilize the injury at the scene by yourself, call for emergency medical services.
- DO NOT move the victim unless the injured area is totally immobilized.
- DO NOT move a victim with an injured hip, pelvis, or upper leg unless it is absolutely necessary. If you must move the victim immediately, use the clothes drag technique.
- DO NOT attempt to straighten a misshapen bone or joint to change its position.
- DO NOT test a misshapen bone or joint for loss of function.
- DO NOT give the victim anything by mouth.
- Use the following six steps:
  1. Check the victim's ABCs. (Open the Airway and check Breathing and Circulation.) If necessary, begin rescue breathing, cardiopulmonary resuscitation (CPR), or bleeding control.
  2. Keep the victim still.
  3. If the skin is pierced by a broken bone, or if you suspect there may be a broken bone beneath an open wound, take steps to prevent infection. DO NOT breathe on the wound, and DO NOT wash or probe it. Cover it with sterile dressings before immobilizing the injury.
  4. Splint or sling the injury in the position in which you found it. It is important to immobilize the area both above and below the injured joint and to check the circulation of the affected area after immobilizing.
  5. Take steps to prevent shock. Lay the victim flat, elevate his or her feet 8 to 12 inches, and cover the victim with a coat or blanket. Do not place the victim in the shock position if you suspect any head, neck, back, or leg injury or if the position causes the victim discomfort.
  6. Get medical help.

FIRST AID: OPEN WOUNDS

ABRASION: **MAT BURN, SCRAPE FROM PAVEMENT.**
(stop bleeding, clean, sterile dressing)

LACERATION: **WOUND MADE BY TEARING.**
(stop bleeding, clean, sterile dressing, sutures if needed)

INCISION: **SLICE IN SKIN MADE FROM GLASS OR METAL.**
(stop bleeding, clean, sterile dressing, suture necessary)

PUNCTURE: **HOLE MADE FROM SHARP OBJECT.** If the object is imbedded deep, leave it in and call an ambulance. If the object makes a small opening:
(stop bleeding, clean, sterile dressing)

AVULSION: **HANGING FLAP OF SKIN. SAVE AVULSED SKIN.**
(stop bleeding, clean, sterile dressing)

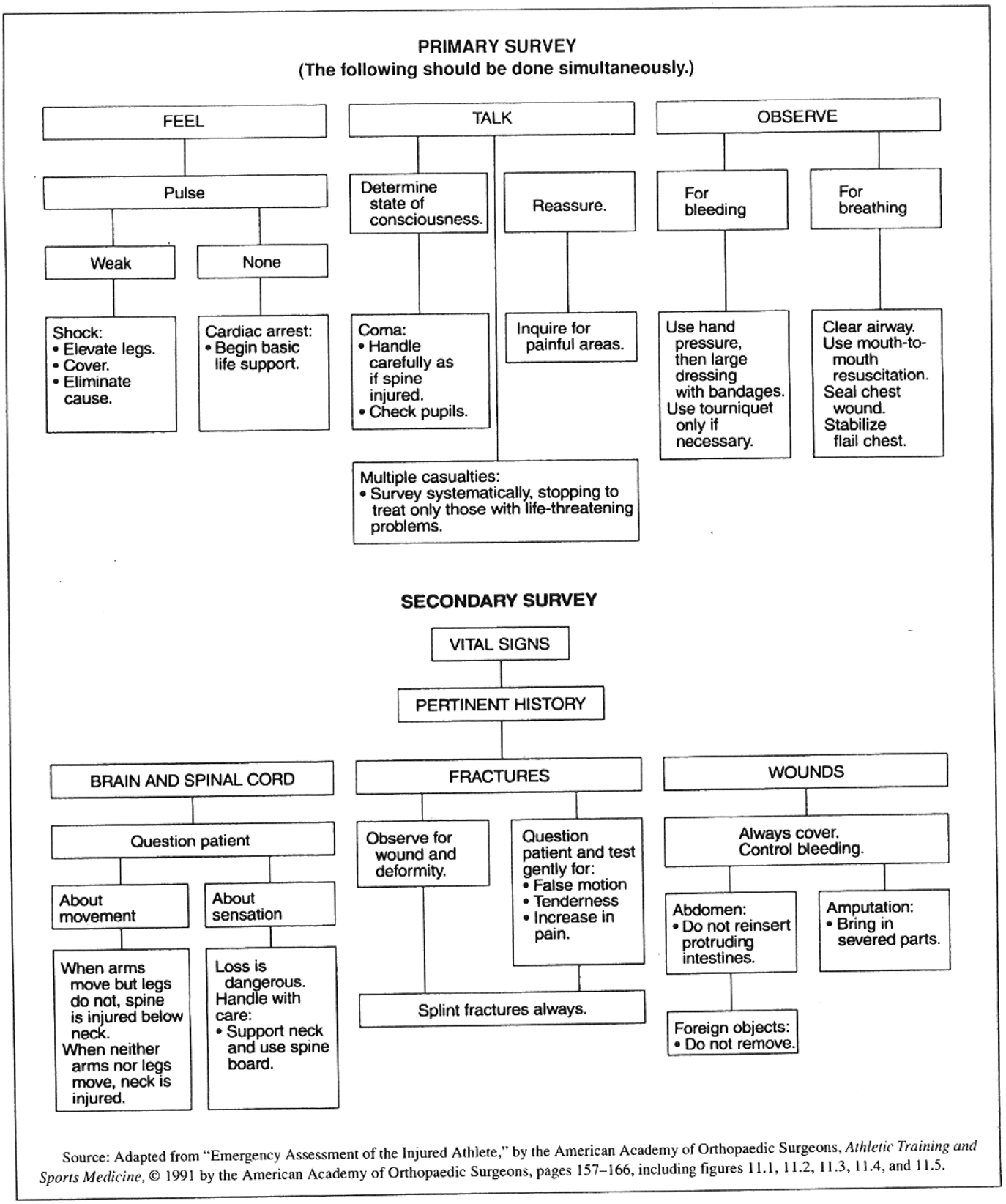
WAYS TO STOP BLEEDING

- DIRECT PRESSURE
- ELEVATE
- PRESSURE POINTS
- ICE

Courtesy of Allen J. Passerallo, The Cleveland Clinic Foundation, Cleveland, Ohio.

EMERGENCIES

ATHLETIC TRAINER'S LIFESAVING SURVEY OF THE CRITICALLY ILL OR INJURED PATIENT



Source: Adapted from "Emergency Assessment of the Injured Athlete," by the American Academy of Orthopaedic Surgeons, *Athletic Training and Sports Medicine*, © 1991 by the American Academy of Orthopaedic Surgeons, pages 157–166, including figures 11.1, 11.2, 11.3, 11.4, and 11.5.

ENVIRONMENTAL/PHYSIOLOGY AND MEDICINE

Wet-Bulb Globe Temperature (WBGT) and Recommended Activity Levels Guide

WBGT		
C	F	ACTIVITY
15.6	60	No precautions
19–21	60–70	No precautions as long as water, salt, and food are easily available
22–24	71–75	Postpone sports practice, avoid hiking
24	76	Lighter practice and work with rest breaks
27	80	No hiking or sports
28	82	Only necessary heavy exertion with caution
30	85	Cancel all exertion for unacclimatized persons; avoid sun exposure even at rest
31.5	88	Limited brief activity for acclimatized, fit personnel only

Examples:

WBGT > 82°F—Consider rescheduling or reducing the race distance. Make frequent announcements about risk of injury.

WBGT > 73°F—If the race is longer than 10K, start before 8 AM or after 4 PM. Advise runners to slow pace, drink fluids, and watch for signs of heat injury.

Wet Bulb Globe Temperature (WBGT) index and use of color coded flags indicate the risk of thermal stress.

- **BLACK FLAG:** Extreme Risk: When WBGT is above 82°F (28°C). Races should be canceled or modified if conditions exceed this level at starting time.
- **RED FLAG:** High Risk: When WBGT is 73–82°F (23–28°C). This signal would indicate that all runners should be aware that heat injury is possible and any person particularly sensitive to heat or humidity should probably not run.
- **AMBER FLAG:** Moderate Risk: When WBGT is 65–73°F (18–23°C). It should be remembered that the air temperature, probably humidity, and most certainly the radiant heat at the beginning of the race will increase during the course of the race if conducted in the morning or early afternoon.
- **GREEN FLAG:** Low Risk: When WBGT is below 65°F (18°C). This in no way guarantees that heat injury will not occur, only that the risk is low.
- **WHITE FLAG:** Low risk for hyperthermia, but possibly risk for hypothermia: When WBGT is below 50°F (10°C). Hypothermia may occur, especially in slow runners in long races, and in wet and windy conditions.

Courtesy of A.J. Cranflocco, MD, Cleveland Clinic Foundation, Cleveland, Ohio.

OH, THOSE ACHING MUCLES: CAUSES AND CONSEQUENCES OF DELAYED ONSET MUSCLE SORENESS*

Every day, scores of people begin new physical fitness programs. In the overzealous beginner who is unaccustomed to strenuous exercise, the initial enthusiasm often turns into the next day's muscle pain and stiffness. Newcomers to fitness aren't the only ones to suffer, however. Even seasoned athletes who increase the magnitude of their training or try a new training regimen become sore. Because soreness doesn't develop until 6 to 10 hours after exercise, it's generally referred to as *delayed onset muscle soreness*, or *DOMS*.

The intensity and novelty of a workout influence how sore a person will be. After mildly intense new exercise, muscle soreness might only be an annoyance that lasts perhaps 30 hours. On the other hand, a very intense episode of exercise might produce pain so great that it limits normal activity for up to a week! Some individuals report trouble getting out of bed; some have to walk downstairs backwards to avoid the pain.

Stiffness and a significant loss of muscle strength commonly accompany delayed onset muscle soreness. In rare incidences, intense overexertion can cause rhabdomyolysis, a life-threatening condition (see box).

Rhabdomyolysis is rare. Adequate physical conditioning for the task and staying well-hydrated by drinking plenty of fluid during exercise are important precautions against rhabdomyolysis. Exercise training should always begin with mild intensity exercise and gradually build up to an appropriate level.

What's It All About?

Muscle soreness is commonly believed to be caused by lactic acid accumulation in the muscle. Not so! Lactic acid is removed from the muscle within an hour or two following exercise so it's not even present when soreness develops. Furthermore, exercises that produce the most soreness produce the least amount of lactic acid.

Muscle spasms have also been touted as a reason for muscle soreness. Again, not so! Studies have shown that muscles are not in spasm when they are sore. Spasms are associated with an increased electrical activity in the muscle (measured by electromyography, EMG). No increase in resting EMG has been identified in sore muscles after overexertion exercise.

*Source: Priscilla M. Clarkson, "Oh, Those Aching Muscles: Causes and Consequences of Delayed Onset Muscle Soreness," *ACSM's Health & Fitness Journal*, Vol. 1:3, pp. 12–17, American College of Sports Medicine, © 1997.

RHABDOMYOLYSIS

Rhabdomyolysis is a rare and serious consequence of overexertion exercise in which muscle proteins such as myoglobin, creatine kinase, and lactate dehydrogenase leak out of damaged muscle into the blood. When critically high blood levels of myoglobin are reached, the protein spills over into the urine and appears as dark or "bloody" urine. When dehydration and heat stress accompany overexertion, added stress is placed on the kidneys, sometimes leading to acute renal failure.

Rhabdomyolysis has been reported in military recruits during basic training, in individuals participating in firefighter fitness tests, and in police cadets during the first week of a training program. Deaths caused by complications associated with renal failure have occurred.

In rare cases, extreme recreational exercise has produced rhabdomyolysis. It has been reported in people hiking into the Grand Canyon without adequate fluid consumption or prior training.

One case involved a 31-year-old man who, after a year of no weight-lifting exercise, performed a very intense resistance training regimen; two days later he was admitted to a hospital with muscle pain and dark brown urine. In another case, a 28-year-old sedentary overweight man, on his first day of exercise, performed intense cycling, rowing, and fast pace walking exercises. The next day, when he was painfully sore and stiff, a fitness counselor recommended that he repeat the same exercise regimen. The man was admitted to the hospital the following day with dark urine. He developed renal failure and needed kidney dialysis for 11 days.

To pinpoint the cause of soreness, scientists have looked for clues from exercises that produce the most soreness. **Exercises that result in the greatest soreness consist of eccentric, or muscle lengthening, contractions.** Eccentric contractions are those in which tension is produced while the muscle is lengthening, such as when a weight is lowered. These exercises are commonly called "negatives."

Eccentric contractions are performed every day as we lift and lower objects. When the objects are very heavy and the exercise is unaccustomed (such as snow shoveling after the first snow of the season), soreness can result. Leg muscles also exert eccentric contractions—with each footfall. Exercises like downhill running or downhill hiking exaggerate eccentric contractions. In the research laboratory, we use

repeated high force eccentric contractions or downhill running to elicit soreness.

Eccentric exercise produce less lactic acid than concentric (muscle shortening) exercise and the oxygen cost is lower, making it metabolically less stressful. However, more force can be generated during eccentric contractions than with concentric contractions so that more weight can be lowered than can be lifted. At the same time, fewer muscle fibers are activated during eccentric contractions which places more stress on the active fibers; this stress ultimately leads to soreness. A hard day of hiking up and down a mountain provides a good example of concentric and eccentric exercise. The uphill portion (biased toward concentric contractions) takes more effort, but the downhill portion (biased toward eccentric contractions) results in delayed onset muscle soreness.

Eccentric Exercise and Muscle Damage

In 1902, before the muscle biopsy technique was used in exercise science, one scientist had the foresight to suggest that soreness was a result of microtears in the muscle caused by eccentric contractions. Muscle biopsies of sore muscles have since proven this theory correct.

The muscle proteins that link together to produce muscle contractions are held in place by other proteins, known as the cytoskeleton, of the muscle fiber. When lengthening (eccentric) contractions are performed, the contractile protein structure can become stretched out, placing stress on the cytoskeletal proteins and breaking them (see box).

These tiny tears result in muscle fiber degeneration, followed by regeneration to rebuild the original structure. White blood cells enter the damaged muscle tissue, clean up the debris of broken proteins, and then initiate the regeneration phase. This process is part of the body's normal inflammatory response to injury. It should be noted that the damage to the muscle fibers is small and occurs sporadically throughout the fiber. Probably less than 5% of the muscle is damaged from overexertion exercise.

How, then, does cytoskeletal damage translate into muscle soreness? The answer appears to rest, at least initially, with the swelling that accompanies the inflammatory process. (Simple circumference measures, as well as measurements from magnetic resonance imaging (MRI) analysis, have documented swelling from eccentric exercise.) The pressure of the accumulated tissue fluid is thought to produce the sensation of soreness, but not by itself, however, because soreness peaks 24 to 48 hours after exercise while swelling is still increasing. During the time of peak swelling, soreness is dissipating.

Muscle sensory receptors respond to different types of stimuli, including mechanical and chemical stimuli. Swelling serves as a mechanical stimulus to activate sensory receptors. When the inflammatory white blood cells enter the muscle fibers, they release noxious chemicals like histamines and prostaglandins that also activate receptors. The initial swelling could be making the muscle more sensitive to the chemical stimuli. The multiple ways in which pain can be elicited in muscle makes it difficult to ascertain the specific mechanism by which swelling produces soreness.

BREAKING THE "BONES" OF A MUSCLE FIBER

The term "skeleton" generally refers to the bony framework of the body. However, each muscle fiber also has a skeleton, called a "cytoskeleton," comprised of proteins that provide the framework for the fiber. The framework must be maintained in an orderly fashion for normal muscle contraction to occur. Contractile proteins, actin and myosin, must be able to easily link and slide together.

Eccentric contractions are thought to stress the intermediate filaments and break them, causing a loss in fiber integrity. Damage to the cytoskeleton during eccentric exercise could provide Z-disk streaming. In the days following exercise, the broken "bones" of the muscle fiber are repaired so that they are as good as new.

Additional Changes in Sore Muscles

In our laboratory at the University of Massachusetts, we use arm flexion exercise consisting of repeated eccentric contractions to induce intense muscle soreness of the elbow flexor muscles. Soreness is not the only effect, however. *Muscle strength* is also affected; study subjects experience a loss of about 50% of their strength, which is not restored for a week or more.

It was originally thought that the soreness of the muscles prevented an individual from giving a maximal strength effort. But a substantial loss in strength remains even as the soreness dissipates. Furthermore, when an electrical stimulation was superimposed onto a maximal voluntary contraction, to determine whether subjects were fully contracting their sore muscles, no greater muscle force was produced, proving that the muscle was already fully activated.

While it is tempting to suggest that damage to muscle proteins causes the strength loss, it can be noted that damage worsens in the day following the exercise as strength is being restored. It has been suggested that the loss in strength

results from overstretched fibers that prevent maximal linking of the contractile proteins.

It's also interesting, and perhaps dangerous, that perception of strength is altered after damage-inducing exercise. As the soreness is disappearing, subjects will state that they are as strong or stronger than they were before performing the eccentric exercise. In reality, however, they may still be experiencing a 20% loss in strength. This inability to accurately perceive strength may increase the risk of injury when exercises that require a lot of strength and coordination are performed, although the risk hasn't been determined. The reduced ability to generate force in the damaged muscles, coupled with the lack of perception of this weakness, may prevent individuals from taking necessary precautions to guard against further overuse and serious injury.

Another change noted after eccentric exercise is muscle *stiffness*. Following the elbow flexion exercise that we use in our lab, the elbow flexor muscles spontaneously shorten. This happens immediately after the exercise and sometimes worsens in the next 48 hours. During the time that the muscle is shortened, a subject is unable to fully extend the arm without pain. This sensation is perceived as stiffness and tightness. Although we do not know the exact cause of this muscle shortening, we do know that it is not the result of muscle contraction in the normal sense. In other words, it's not caused by depolarization of the muscle fibers. Electromyographic analysis has shown that there is no depolarization of muscle fibers in the shortened muscle. If we believe that overstretched fibers result from performance of eccentric exercise, then how can shortening occur at the same time? It is possible that the connective tissue structures around the muscle fibers shorten to support the weakened fibers. Also, the previously mentioned muscle fiber swelling could produce the shortening. Or, there may even be small spontaneous contractures in some fibers; calcium can accumulate inside the fiber because of damaged membranes, and the increased intracellular calcium could activate the contractile proteins and cause contractures. Again, a combination of factors is probably to blame and makes it difficult to pinpoint the exact cause.

Muscle soreness and stiffness may be just an annoyance, but loss of strength and range of motion can affect the ability to perform. Because sore muscles are generally weakened and there is an accompanying loss of neuromuscular function, training with sore muscles may not be the most effective way to achieve optimal performance.

Repeated Bout Effect: *It May Not Hurt So Much Next Time*

Several years ago, my colleagues and I performed a pilot study to test the effect of heat during exercise on the development of muscle soreness. On their first visit to the laboratory, two subjects performed an arm exercise with one arm in a water bath of room temperature water. On their second visit, the subjects performed the same exercise but with the arm in warm water. We found that muscle soreness was considerably less after exercising in the warm water. Did this mean that muscle soreness could be prevented or reduced if the muscles were very warm? We decided to perform a properly controlled study in which some subjects exercised in the room temperature water first while other subjects exercised in the warm water first. Two weeks later they performed under the opposite conditions. We were surprised by our findings. The second bout of exercise, regardless of water temperature, resulted in less muscle soreness.

We had discovered the *repeated bout effect*. Performance of one bout of exercise made the muscle less susceptible to damage. We thought it remarkable that after two weeks with no intervening exercise that the muscle had adapted and "remembered." We were even more surprised to find that the adaptation lasted up to six months!

How can this long-lasting repeated bout effect be explained? One study found that the inflammatory response is less pronounced upon performance of the second bout. Another suggests that repaired muscle fibers are slightly longer so that the effects of a stretch (eccentric contractions) are less damaging. Another possibility is that there is a change in how the nervous system activates the muscle; the process may become more efficient, thereby placing less stress on active muscle fibers. A combination of factors may play a role in the adaptation process.

It is interesting to note that the repeated bout effect can be elicited even when the first bout of exercise is only moderately intense. If an individual performs an exercise that produces little muscle soreness, an adaptation will still result and the desired "training response" will be achieved. This information is helpful in starting an exercise program because it suggests that soreness can be minimized if a person starts the exercise program gradually. Even well-trained athletes who dramatically increase or change their workout will develop muscle soreness; they, too, can benefit by making gradual adjustments to their workouts.

When Muscles Hurt Anyway

Topical analgesics, nonsteroidal anti-inflammatory drugs, heat, cold, massage, and electrical stimulation are among the many treatments used against muscle soreness. Most are either ineffective, minimally effective, or temporarily effective. **No treatments have been identified that prevent or permanently reduce muscle soreness.** Any beneficial effects of some of the products on the market are typically short lasting; within a few hours soreness resumes its normal time course.

Probably the reason so many products and treatments exist is that temporary relief, even though it's short lasting, offers some respite from intense soreness. The supposed success of some therapies may actually be a result of the repeated bout effect rather than the treatment itself.

Soreness can be minimized by limiting movement, since pain is elicited when the muscles are used. Precaution is the best way to avoid soreness; engage in prior physical conditioning using the same type of exercise but at a lower intensity.

Unaccustomed strenuous exercise (especially exercises that are biased toward eccentric muscle contractions) can damage muscle fibers. Analysis of muscle biopsy samples has confirmed damage to the muscle contractile proteins and to proteins that provide mechanical integration of the fiber. Other indicators of damage include a loss of muscle strength, reduced range of motion, muscle stiffness and soreness, and an elevation of muscle specific proteins in the blood. In rare instances, muscle damage can result in kidney failure, especially if accompanied by heat stress and dehydration. During any overexertion exercise, it is important to drink plenty of hydrating fluids.

Recovery after strenuous, unaccustomed exercise is relatively slow so that soreness and decrements in performance can last five to 10 days. Because sore muscles are weak and damaged, training with sore muscles can be inefficient and may lead to further damage and injury.

Muscle damage from exercise is repairable. An adaptation, or training, effect occurs during the repair process. The muscle becomes more resistant to subsequent strenuous exercise so that less damage occurs and the repair process is accelerated. Only a short period of specific physical training of moderate intensity is necessary to produce this training effect.

Traditional treatments for soreness—like nonsteroidal anti-inflammatory drugs, cold, heat, massage, and electrical stimulation provide only minimal or temporary relief. The best means to prevent or reduce muscle damage and muscle soreness is prior physical conditioning.

ECCENTRIC EXERCISE IN SPACE

Astronauts who have been in space for as little as one to two weeks experience shrinkage of skeletal muscle mass and a decrease in muscle strength. Because of the advent of the space station, it has become increasingly critical that they maintain muscle strength and mass. Astronauts will be spending longer periods of time aloft and will have to perform demanding physical tasks to build and maintain the station.

Scientists are currently determining the types of exercise to recommend in space. Resistance training regimens consisting of concentric contractions alone are not as effective in promoting muscle growth and strength as regimens that combine concentric and eccentric contractions. Presently, because of the lack of gravity in space, astronauts perform virtually no eccentric contractions.

When astronauts return to earth, they are faced with a sudden onset of force and stretch on their leg muscles (eccentric contractions). This can result in muscle soreness and a further loss in muscle function. After a long space flight, even eccentric contractions of low intensity (as those occurring in walking) are new. Any emergency situation during landing that required astronauts to produce high eccentric forces would leave them vulnerable to serious injury.

Because exercise countermeasures in space should include eccentric contractions, exercise machines that can provide eccentric exercise capabilities are being developed. One machine, designed by Per Tesch, Ph.D., of the Karolinska Institute in Sweden, works like a yo-yo. It is basically a fly wheel with a cord attached. A handle on the cord allows exercisers to first unwind it using a concentric contraction. Once the cord is unwound from the flywheel, it starts to rewind; the exerciser must resist the rewinding by performing an eccentric contraction. The device is simple, easy to use, and requires no electrical power source. It is likely to prove very valuable for performing resistance exercise during space flight.

SAY "AHHH": A PRIMER ON PAIN KILLERS*

Attorney Jim Hage is the Cal Ripken Jr. of running. On August 16, 1982, just three months after the Baltimore Orioles third baseman began his consecutive-games streak, Hage started his consecutive-day running streak. And like Ripken, he hasn't missed a day since.

We know what that means for Ripken: more than 2,600 games without a break and the open-mouthed awe of baseball fans everywhere. For Hage, however, the iron man's spoils have been more modest: nearly 6,000 consecutive days of fanfare-free running. And the undying gratitude not of Little Leaguers—but of the makers of ibuprofen.

"I have a stash with me wherever I go," the 2:15 marathoner reveals with a guilty grin. "In my gym bag, at my desk at work, in the glove compartment . . . you name it, I have it stocked. If I don't take ibuprofen before I run—every time I run—my sciatica really makes me pay the next day."

Granted, few of us run 16 days straight—much less 16 years. But some of us do rely on caches of capsules and tablets to shoulder us through our workouts, injuries, and race days. We pop Advil, Nuprin, and Motrin (all forms of ibuprofen) the way kids scarf Skittles—despite the fact that these "runner's little helpers" have a variety of spelled-out-on-the-box risks.

Is there a hidden price for this miracle fix? If you take these drugs routinely, are you risking damage to your stomach and kidneys? In other words, will Hage end up paying anyway—and will you?

The Straight Dope

Aspirin, the original anti-inflammatory, has been around for ages—long before Frederick Bayer started selling it as an over-the-counter painkiller in 1899. And while it's still the most widely sold painkiller and anti-inflammatory in the world, these days it has lots of company.

The Big Five nonprescription pain relievers now on the market are aspirin, ibuprofen (Nuprin, Advil, Motrin), naproxen sodium (Aleve), acetaminophen (Tylenol, Excedrin), and ketoprofen (Actron, Orudis). All five relieve pain associated with muscle aches and stiffness. And all reduce fever. But only four—aspirin, ibuprofen, naproxen sodium, and ketoprofen—also reduce inflammation. That's why they're called "nonsteroidal anti-inflammatory drugs," or NSAIDs (pronounced "enseds") for short.

These drugs work by curbing your body's production of cyclooxygenase, an enzyme responsible for producing hormone-like substances called prostaglandins. The sorority sisters of the body, prostaglandins have their hands in all sorts of functions—including the development of pain and inflammation. That's why, if you pop an Advil or an Aleve, you'll feel less pain and suffer less inflammation.

Here's what happens. Let's say you sprain your ankle while on the trail. "The muscle damage a doctor would see immediately after your mishap is due to the injury itself. But from research we know that additional muscle damage occurs due to inflammation that arises from the trauma," explains Lucille Smith, Ph.D., an exercise physiologist and associate professor of health, leisure, and exercise science at Appalachian State University in Boone, N.C. "And, while mild inflammation *initiates* healing and is the *only* way we can heal, extreme inflammation creates damage of its own." In other words, some inflammation is good; a lot of inflammation is bad.

The trick is to manage the inflammation, which is where anti-inflammatories come in. "If you've just finished a marathon, or if you have a serious, nagging running injury, you'll probably be experiencing a lot of inflammation along with it," says Smith. "In these cases, an anti-inflammatory is probably called for. But if you're just a little sore, such as after an interval session on the track, you're likely experiencing a lesser degree of inflammation, which would promote healing. In these situations, go with acetaminophen, which relieves pain without reducing inflammation."

Words of Caution

So far, so good. Here's one important caveat: Remember, pain is the body's way of telling you that something's wrong. You're supposed to listen, not just erase the thought the way you would a typo. Take painkillers only to facilitate the healing process. While taking them, decrease your mileage or stop running altogether. Don't take painkillers to help maintain a hard training program or to allow even harder training.

This leads to a second caveat: Don't take painkillers before or during a marathon. Many runners do this in hopes of delaying or preventing the tightness and soreness that come late in the race. Not a good idea; take them *after* a marathon, when you are thoroughly rehydrating. Though rare, there are several documented cases of runners who have suffered kidney failure after taking NSAIDs before or during a marathon.

Third and final caveat: Beware of chronic use, as those prostaglandins that NSAIDS inhibit also protect your stomach lining and maintain proper bloodflow to your kidneys. So when you take anti-inflammatories for months or even years at a time, you may experience stomach ulcers or kidney damage.

Just ask Kenny Easley, former football star with the Seattle Seahawks. He sued his team in 1989, alleging that the abundance of NSAIDs available in the team training room led to his kidney failure and eventual kidney transplant.

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While the Seahawks denied any wrongdoing and eventually were dismissed as defendants (the suit was settled out of court), the specter of Easley often hangs over discussions about anti-inflammatory use in athletes.

"Clearly, the Kenny Easley case showed us that NSAIDs are not entirely safe drugs," says Paul Thompson, M.D., director of preventive cardiology at Hartford Hospital in Connecticut, president of the American College of Sports Medicine and a longtime runner. "I'm not against using them, of course. But if you have so much pain that you need to take them routinely, that's a problem. I'd rather see you figure out why you have the pain, not risk your health—even if the risk is admittedly minimal—by masking the pain with anti-inflammatories."

So be smart. If you do that, you'll be fine. "Nonsteroidal anti-inflammatories such as ibuprofen are definitely the most common medication I prescribe in my sports-medicine practice, and I haven't seen a single serious problem with them in 15 years," says Warren Scott, M.D., director of sports medicine at Kaiser Permanente Medical Center in Santa Clara, Calif., and a longtime runner. "You do hear of it, of course—people who develop serious stomach trouble, for instance, after taking anti-inflammatory medication. But those people are usually ill to begin with. For healthy people, and certainly for athletes, using anti-inflammatories, even for years, generally doesn't pose a problem if you take them correctly."

Here are three important strategies for doing just that.

1. Always take anti-inflammatories with plenty of fluids.

"When you become hydrated, all your body fluids thicken and become more concentrated," explains Dr. Scott. "So if you get dehydrated while you're taking NSAIDs, the drug becomes more concentrated, which increases the risk of kidney damage."

To ward off dehydration and any related kidney problems, make sure you drink plenty of fluids while you're taking ibuprofen or other anti-inflammatories—*especially* if you are running long distances (when the threat of dehydration rises) or are over the age of 60 (when your kidneys aren't quite as spry as they used to be and may have trouble handling drugs and dehydration). Also, avoid alcohol while taking anti-inflammatories. Alcohol can irritate the stomach. Plus, it's always a good policy to take just one drug at a time.

2. If you need to take anti-inflammatories for a month or more, you may need to monitor their effect on kidney and liver function.

"To make sure you're not damaging your stomach or kidneys with anti-inflammatories, you should get liver- and kidney-function tests—both are simple blood tests—after you've been on the drug for four weeks straight," says Dr. Scott. "If you're still on anti-inflammatories after six months, you should get tested again. If both tests come back normal, you can assume the drug is having a strictly therapeutic effect on your body, and that it will continue to have a therapeutic effect for as long as you take it." Provided, of course, you don't increase your dosage, or start taking another medication in addition to anti-inflammatories, or start drinking alcohol regularly after you were last tested.

3. *Gradually* take in the amount of anti-inflammatory necessary to reduce inflammation.

Let's say you want to reduce the inflammation in your severely strained Achilles tendon. If you were to pop 400 mg of ibuprofen (the maximum dosage recommended on the label), you would reduce the pain but probably not the inflammation, says Dr. Scott. With ibuprofen or any other anti-inflammatory, it takes about five doses to build up to the amount necessary to reduce inflammation.

Just be sure not to dose up all at once. No, you won't poison yourself by taking twice the recommended dose (physicians often prescribe this), but you will increase your chances of experiencing side effects such as stomach upset. To sidestep the latter *and* get a full dose of anti-inflammatory medication, Dr. Scott recommends the following regimen:

If you have an injury such as Achilles tendinitis or shinsplints, which may prevent you from running for a month or more, start with the dosage recommended on the bottle. After four or five days, increase it by 25 percent. Wait another four or five days, then increase it again by 25 percent. If that dosage controls the pain and appears to relieve the inflammation, stay on it for a week, then decrease it by 25 percent. If you're still getting relief, stay on the new dosage for another two weeks. If you're not, increase the dose by 25 percent and stay on that dosage for another two weeks. Then stop taking it altogether and see how you feel.

For less serious injuries, you're probably fine to stay with the dosages recommended on the label as you ease back on your training. For a very mild injury or for muscle soreness, acetaminophen may be all you need.

***Note:** If you are pregnant, are drinking more than the equivalent of three beers a day, or are currently taking medication of any kind, consult your doctor before using any nonprescription pain reliever.*

POP PHYSIOLOGY

There's Advil. And Actron. There's Nuprin, Motrin, and Aleve. Orudis, the new guy. And Genuine Bayer Aspirin—the old standby. You name it, pharmacies have it—in a vast variety of formulas and a wide range of prices. How the heck are you supposed to choose among anti-inflammatories? Here's a tip: All those brands and formulas are more similar than they are different.

That's right. While there are three chemical classes and many more subsets of anti-inflammatories, all the brands favored by runners fall within a single chemical class called the carboxylic acids. Which means their chemical properties are all very similar, as are their side effects.

Still, if you find yourself taking anti-inflammatories over an extended period, you may want to experiment with various brands and formulas, just to see which works the best and produces the fewest side effects. "My patients and I check out the over-the-counter drugs first," says Warren Scott, M.D., director of sports medicine at Kaiser Permanente Medical Center in Santa Clara, Calif., and a long-time runner. "Then, if necessary, we try prescription drugs."

Here's a quick primer on the variations of anti-inflammatories you'll find.

- **Enteric-coated anti-inflammatories.** These pills have a special coating that allows them to pass through your stomach and dissolve your small intestine, which supposedly helps reduce stomach irritation. But the pills control pain and inflammation exactly the same way all anti-inflammatories do—by curbing your body's production of prostaglandins, which are necessary for maintaining the stomach's protective lining. So regardless of where they dissolve, they may still irritate your stomach. And their enteric coating delays absorption, so you may not want to use them for immediate relief.
- **Buffered aspirin.** Like enteric-coated anti-inflammatories, buffered aspirin has a coating designed to minimize stomach upset. But by blocking the body's production of prostaglandins, buffered aspirin may still irritate your stomach. And that "buffer" slows absorption of the medicine.
- **Liquid formulas.** Not just for kids and pill phobes anymore, liquid pain relievers like Alka-Seltzer (which is liquid aspirin) are absorbed by your body much faster than tablets or capsules (which can take about an hour and a half). So they're perfect for people with acute pain.

  For fast-acting pain relief, try Alka-Seltzer for the first dose, followed several hours later by an anti-inflammatory such as Advil or Aleve.
- **Caffeine-enhanced formulas.** Some analgesics and anti-inflammatories contain caffeine to boost their effect—or so the drug makers claim—either by increasing the speed at which your body absorbs the drugs or by lifting your mood. What they're certain the caffeine definitely won't do, however, is improve your performance. The pills pack too little of the good stuff for that.

PILL TRAINING

Here are the nine most popular pain relievers among runners, and their track records.

Drug	Active Ingredient	Purpose	Side Effects
Actron, Orudis KT	Ketoprofen	Relieves pain and inflammation; reduces fever	Stomach upset, bleeding, and ulcers; kidney damage (very rare)
Advil, Motrin IB, Nuprin	Ibuprofen	Relieves pain and inflammation; reduces fever	Stomach upset, bleeding, and ulcers; kidney damage (very rare)
Aleve	Naproxen sodium	Relieves pain and inflammation; reduces fever	Stomach upset, bleeding, and ulcers; kidney damage (very rare)
Bayer	Aspirin	Relieves pain and inflammation; reduces fever; protects against heart attacks by thinning blood	Stomach upset, bleeding, and ulcers; kidney damage (very rare); ringing in the ears
Excedrin Aspirin-Free	Acetaminophen, caffeine	Relieves pain; reduces fever	Liver damage (only after prolonged use and very rare)
Tylenol	Acetaminophen	Relieves pain; reduces fever	Liver damage (only after prolonged use and very rare)

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