The Great Stretching Debate

By Tamara Mitchell

After years of participating in sports and exercise of many types, and listening to coaches and fitness experts, we have had it engrained in us to warm up, stretch, exercise, cool down, and stretch again. But a review of 361 research studies conducted by the epidemiology program office at the Centers for Disease Control and Prevention (CDC) concluded that there is no evidence that stretching before or after exercise prevents injury or muscle soreness.[1,2] Since that review was done, conflicting research continues to indicate that not only is stretching controversial, but that it is a fairly complex topic.

Medical and nutrition advice seems to take a 180-degree turn every time we tune in, so perhaps it's no surprise after all. The CDC review included hundreds of studies, many of them testing hundreds or thousands of subjects. The review even weighted each study so weaker research received less consideration than rigorous studies. But there were still many unanswered questions. What type of stretching was studied? What type of exercise was studied? Is stretching actually bad to do, or is it just not helpful? More recent research has started to delve into these questions. It turns out that these questions are critical to understanding the merits, uselessness, or harm of stretching. Too many research articles are poorly designed and do not isolate the variables to enable clear conclusions, so answers to these questions remain somewhat uncertain.

The CDC research review concluded that there isn't sufficient evidence to either recommend that people *stop* stretching, nor good evidence that people *should* stretch. Recent research is attempting to differentiate between the types and duration of stretching and it's effect on performance and injury rates.[3]

One of the results found in stretching research is that, when you stretch for just a few of seconds, the muscles retract back to their original tension fairly quickly. If one stretches for 30 seconds or more, the muscles actually stay stretched out for a bit longer, but the total time necessary for long stretches of many muscle groups adds a great deal of time to the ordinary workout and it must be done at least 3 times a week to be effective.[4] In observing every other animal on earth, you do not see them holding their legs in a stretch position for 30 seconds prior to a chase, or ever! At the same time, you don't see panthers or even household dogs and cats suffering from tight hamstrings or pulled muscles on a regular basis.

There is a relatively new area of thinking, apparently starting in the late 1980's that began looking at the activity called "pandiculation". When we observe our dogs or cats waking up from a nap, either in the prone position or standing, they appear to stretch and often yawn. Humans often do something similar, though society has put a damper on many of these behaviors as inappropriate displays in public. Yawning in almost all cultures is considered rude.[6, 7] What

animals are actually doing is pandiculating. It looks a lot like stretching, but it actually arises from a totally different part of the brain, it's involuntary, and it involves a tensing of all muscles, extending the legs, arching the back, reaching out the shoulders, and a variety of other behaviors quite different from the voluntary stretching of one muscle group that humans have been doing in their attempt to relax muscles.[5,6,7] The nature of pandiculation appears to serve to regularly restore and reset the structural and functional equilibrium of the myofascial and musculature system.[6,7] We will discuss this in more detail in this article after we discuss traditional stretching and research results.

Stretching at work

This article addresses stretching with regard to injury prevention and performance during exercise. We still encourage everyone to stretch and pandiculate during the workday to relax and lengthen tense muscles and improve circulation during rest breaks. The problem with working at a computer is that your body is held relatively rigid for a long time. As we will discuss, the natural thing for animals to do after a period of inactivity is to pandiculate. Stand up, yawn, reach for the stars! It will reduce the potential for Repetitive Strain Injuries associated with office and lab work. If you have only a few moments to spare, allow yourself to do what nature is begging you to do. We feel that this resetting of the fascia throughout the day is extremely important to the prevention of repetitive strain injuries and other injuries that result from being sedentary for many hours at a time.

Flexibility: Injuries and Performance

Stretching does improve flexibility, but flexibility doesn't prevent sports injuries, as found in the CDC review.[1,2,8,9] Flexibility can be attributed to various factors including muscle range of motion as well as joint capsule and ligament properties.[9] Joint hyperextension or instability is usually caused by genetic factors and stretching can be detrimental to people with these conditions.[9]

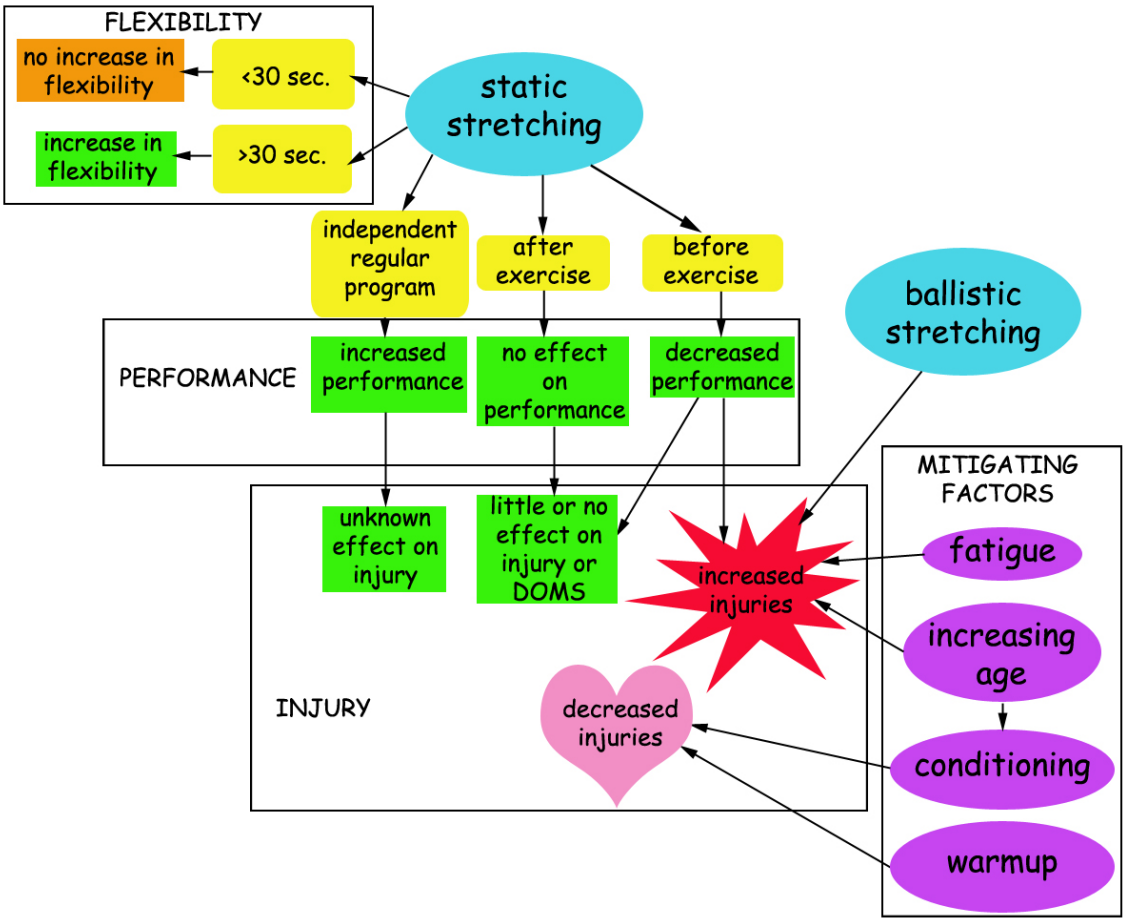
Most injuries happen when the muscle is going through its normal range of motion, so having an increased stationary range of motion probably has no effect on preventing such injuries.[2,8] In fact, an increased range of motion at a joint can actually increase the instability of the joint. Some research has indicated that athletes who are in the highest 20% of the flexibility continuum are the ones with the highest injury rates.[1,8]

Certain types of flexibility, however, are important in sports such as gymnastics, diving, ice skating, and dance.[1] The best data indicate that performance might be lowered at the extremes of flexibility and that, at least for some muscle/joint groups, there might be optimal levels of flexibility that would enhance performance.[1] These benefits are likely to be specific to a sport or even to a specific body movement.[1] More research is needed to understand this relationship.

Most of the research looked at static stretching (i.e., long, slow stretches). It is already well known that ballistic stretching is very likely to cause injury due to bouncing and repeated rapid stretches.[1,8,10]

The following diagram illustrates and summarizes the main research findings with regard to stretching.

Relationship of stretching to flexibility, performance, and injury



Stretching before exercise: Injuries and performance

The traditional theory of stretching before exercise is that it will limber up muscles and prevent injury. Studies with hundreds of subjects have been conducted with various controls and they seem to come up with similar results. Stretching before a rigorous workout (varying from running, army basic training, to martial arts) has consistently been shown to *have no significant effect on injury rates* during exercise.[1,8,10,11,12] It is, at best, a waste of time.

If you try to make a fast, dynamic movement immediately after a static stretch you *may injure* the stretched muscles.[5] The more strenuous the stretch (closer to the pain threshold), the more likely the injury.[5] Even mild static stretching *can damage muscle cells*. Static stretching also increases pain tolerance.[1,5] With an increased tolerance to pain, it is not wise to exert the muscle immediately afterward in its anesthetized state.[5]

There are contradictory results regarding the extent of the effect of static stretching on performance, but all research has shown that relaxed static stretches decrease strength by impairing activation of the stretched muscles for up to five minutes and contractile force for up to one hour.[5] Stretching a relaxed muscle prior to exercise has been shown to result in loss of strength due to a *neural effect* rather than an effect on muscle tissue or other soft tissue

alteration.[3] Some research has shown that, except for elite level athletes, the difference in performance force, power, and economy of motion (e.g. running speed) is very little either for stretching right before exercise or regular stretching. For elite athletes, there is a slight decrease in force and power, but an increase in economy of motion if stretching is done just prior to exercise.[9] In other research, stretching has been shown to temporarily decrease muscle strength by 20% in both humans and animals.[8,10] Other research indicates that passive stretching in animals can reduce the force required to damage muscle by as much as 25-30%.[8]

Static stretching has very little resemblance to the rapid-fire muscle contractions during a workout (e.g., elongating your hamstrings does little to prepare them for the upcoming endurance required) and thus may have little chance of preventing injury.[8] In addition, dynamic range of motion is generally greater than static range of motion due to enhanced tissue elasticity and relaxation of opposing muscles when one muscle group is contracted.[1] In static stretching, opposing muscles are not contracted as sthe one muscle group is stretched (or relaxed). Since most injuries are due to overuse, stretching does nothing to prevent injuries of this type.[8]

One study of males who ran the same number of miles per week found that those who stretched before training had a 33% greater risk of injury than the non-stretching runners.[8] This is true even after discounting the runners who had a high risk of injury due to a previous injury, and who might be stretching more as a result. Interestingly, it was found that the highest injury rate only applied to Caucasian males. Females had the same injury rate for stretchers and non-stretchers. Asian runners also had the same injury rates for stretchers and non-stretchers. The only weakness in this study is that it did not control for the type of stretching, so we don't know if the white males were perhaps more likely to rush stretching using ballistic stretches.

Stretching after exercise?

The theory behind stretching after exercise is to relax tense muscles and help the body rid the muscles of lactic acid (a waste product that accumulates during exercise). First, and most conclusive, is the fact that lactic acid does not cause muscle soreness.[13] Blood and muscle lactate levels typically return to normal values after 30-60 minutes of recovery. The pain associated with delayed onset muscle soreness (DOMS) peaks after 24-72 hours, well after the lactate levels have returned to normal.[13]

Research has found that DOMS is most severe with eccentric exercise and less severe with concentric exercise.[13,14] Concentric exercise works muscles in pairs: when one contracts, the opposing muscle relaxes. There are no forces in the direction opposite the motion. Eccentric exercise involves motion where muscles are stretched as they attempt to contract. Instead of initiating an action, the activated muscle acts as a brake to restrain action. Examples of concentric exercise are running on flat terrain, throwing a ball, or raising a dumbbell. Examples of eccentric exercise are walking or running downhill, landing from jumps, performing squats, attempting to come to an abrupt stop at the end of a short sprint, slowly lowering a heavy object held in the hands, or plyometrics. This type of activity can result in muscle soreness.[13,14] If DOMS were caused by lactic acid build-up, it would be expected that muscle soreness would be higher from concentric exercise that requires greater energy expenditure where more lactic acid is produced. The opposite is actually true, where eccentric exercise has been shown to produce DOMS at little metabolic cost with less lactic acid production.[13]

What appears to cause DOMS is a breakdown of protein structures within the muscle.[13,14] In addition, inflammation and stiffening of the connective tissue matrix causes activation of pain receptors, resulting in DOMS.[13,9] Finally, the slow release of substances such as bradykinin, histamine, and prostaglandins by damaged cells stimulate and sensitize pain receptors.[14] After

eccentric exercise that causes proteins to break down, the body builds new muscle fiber to make protein structures even stronger and more resistant than before.

The study noted in the previous section that found higher injury rates in white males actually found lower injury rates for runners who stretched after their workouts.[8] Other research shows that stretching before and after has no effect on muscle soreness.[1,8] Research does not support the effectiveness of anti-inflammatory drugs, antioxidant supplements (vitamins C and E), ultrasound and TENS, stretching, ointments or creams.[13,14] Aspirin taken orally and topically applied as a cream has shown to potentially reduce, but not eliminate, soreness.[14]

The best method for avoiding DOMS is to perform additional bouts of the same exercise that caused it, in addition to a general warm-up for 5 minutes and specific mobility exercise for 15-20 minutes prior to strenuous eccentric muscle activity.[13] Research has shown that even a single bout of the same exercise performed every week can keep the muscles permanently adapted so that DOMS is prevented.[13,14] Starting an exercise program so that the increase in eccentric exercise is gradual will help avoid severe DOMS.[13] Since the muscles respond by rebuilding even stronger, the soreness will diminish with each session and will eventually vanish.

Regular stretching program

A program of regular stretching not performed right before exercise actually increases force, power, and economy of motion.[9] Most people who perform any type of sport with seriousness engage in not only training for and participation in the sport, but also some sort of strength training regimen. Strengthening muscles that oppose the muscles generally used in the sport is useful in preventing imbalances and injury. Yoga and Pilates are both additional ways to balance the body's energy, increase core strength, and stretch muscles in a program that can be performed independently from sport participation. Yoga is excellent training in mind/body focus, energy balancing, and coordinating breath and movement.[15] Pilates works the whole body and emphasizes control, balance, concentration, flow, breathing, centering, and precision of movement.[15] Pilates works on strength, flexibility, and balance. Both yoga and pilates would provide excellent ways to include regular stretching and strengthening into your life in an overall program of injury prevention.[15]

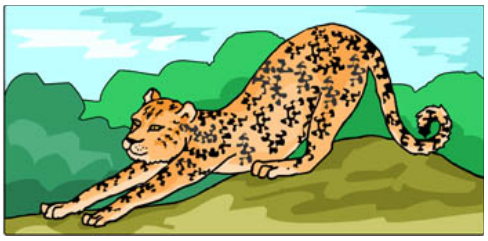
How to stretch

Stretching of sore muscles may further damage them.[10] Research has shown that stretching may cause DOMS by increasing damage. If you feel that a stretch may relieve spasms in sore muscles, stretch very lightly, just enough to feel relief.[10] Stretching to relieve muscle spasms is effective. All stretching should be done when muscles are warm and the body is sufficiently conditioned.[1]

Research has shown that for people under 40, stretching for 30 seconds is more beneficial than stretching for 15 seconds, and stretching for 60 seconds is no more effective than stretching for 30 seconds.[11] In addition, 30-second stretches need to be performed no less than 3 times a week to be effective.[4] For older people, up to age 97, a 60-second stretch was found to be more effective than either a 15 second or a 30 second stretch.[16] This total stretch time can be broken up into short but frequent stretches, which has been found to be just as effective as one longer stretch.[16]

Enter: Pandiculation!

Pandiculation is the involuntary stretching of the soft tissues which most animals engage in most often after rising or when waking.[5,6,7] Yawning is considered a type of pandiculation and sometimes occurs simultaneously with the pandiculation of other body parts. The combined behavior is called stretch-yawning syndrome (SYS).[6,7] It is conjectured that SYS serves to maintain the animal's ability to move in an integrated and coordinated manner by restoring and resetting the structural and functional equilibrium of the myofascial system and resetting muscle length.[6,7] Pandiculation differs from stretching in that it begins with a conscious, voluntary contraction of a muscle group(s) past their point of normal static tension.[17] The joints and limbs are extended to their maximum length or the body is arched with the muscles contracted to their maximum. After the peak, the soft tissue tension level plummets yielding a sense of pleasure and well-being.[6, 7, 17] It appears to be a corrective response to the stiffness induced by temporary positional stress or immobility (sitting still for a while or sleeping).[6, 7] Examples of pandiculation in the animal world include arching of the neck, straightening of the back and full extension of one or the other hind leg, dogs and cats stretch their forelegs forward together while depressing the shoulders and back, and cats reach forward or up in this posture while performing "claw sharpening" acts.[6, 7] The movements may also involve the tail, rotation or deviation of the head, sometimes the eyes are closed, and extension of the joints occurs so that an entire stiffening and extension of the extremities and trunk is involved.[6, 7]



It is thought that pandiculation is governed by the limbic system, a system which controls many involuntary movements such as chewing, locomotion, shivering, sexual function, laughing, crying, and defense reflexes.[6, 7] Voluntary imitation of such involuntary movements will not produce the same results and not the same sense of well-being and satisfaction.[6, 7] Think of when you try to yawn consciously. It is often incomplete and unsatisfying. Pandiculation can be initiated at the conscious level, but at a certain point the involuntary sequence can take over and complete it. Among humans, pandiculation and yawning in particular are frowned upon in polite company, so it has been suppressed to a large extent by societal pressures.[6, 7] Since pandiculation appears to be a very successful way of resetting the muscle length and the fascia, suppression of SAS in humans may well be the source of many of our musculoskeletal disorders.[6, 7]

Pandiculation involves the nervous system and the brain which differs significantly from static stretching which is a passive activity not involving the brain or nervous system.[17] Static stretching simply involves passive lengthening muscles and ligaments, while pandiculation involves active contraction of all opposing muscles as the skeleton and joints are extended and flexed.

Hanna Somatics and Muscular Repositioning (Rolfing) work in a similar manner to reset the fascia. Hanna Somatics teaches pandiculation as a way to reset muscle length and regain brain-level control of both the muscles and movement.[17] Rolfing may be similar in that it consists of manually inducing co-contraction of opposing muscle groups.[6] In Hanna Somatics and another similar types of stretching called Propriceptive Neuromuscular Facilitation (PNF) call for contraction of a muscle group and then relaxing it or stretching it after the contraction.[17, 18,19]

For some reason, pandiculation has been overlooked in the research of stretching, but we feel that it is actually a critical component of conditioning the fascia following a period of inactivity. We

hope that future study can focus on pandiculation and it's contribution to injury prevention and performance in contrast to traditional cerebral/voluntary stretching.

Warm-up is important

Research continues to recommend warming up prior to exercise.[1,2,8,13] Warming up reduces muscle stiffness rather than increasing range of motion.[8] Stiff muscles are very resistant to changes in tension and possibly much more susceptible to injury.[8] An active warm up also increases muscle temperature which enhances muscles' resistance to tearing. This increase in temperature can decrease stiffness and minimize the risk of muscle and tendon injuries during a workout or sport activity.[8]

Warming up consists of at least 10 minutes of exercise at a low level of activity. Replace stretches with dynamic activities that resemble the actions that are to follow in the workout or competition, gradually increasing intensity and eventually mimicking the intensity of the most strenuous moments of the activity. This prepares the neuro-muscular system for the workout ahead. For example, running at a modest intensity for 10 minutes has been found to be effective for reducing the active stiffness of leg muscles.[8] There may be optimal levels of warm-up related to fitness of the person involved, since fatigue has detrimental effects.[1]

Passive methods to increase body temperature (hot baths, moist heat) also tend to increase performance, but to a lesser degree and the effects of massage were not consistent.[1] There is no information on these methods with regard to reducing injury.

Good conditioning is best

Research indicates that the best predictor of injury is how conditioned the person is. A person who is in better shape is less likely to get injured.[8] Conditioning also prevents muscle soreness after exercise. There is strong evidence that strength training, conditioning, jump training, proprioception (balance) training and warm-up play an important part in injury prevention.[1] But too much is not a good thing. Higher injury rates are associated with overtraining. (e.g., high-mileage runners who have very long workouts have more injuries than low-training-volume runners.[8]) Fitness level has been shown to be highly related to probability of injury. One study found that an individual's 20-meter shuttle run time was a good predictor of injury. This assessment accurately predicts maximum oxygen capacity and running capacity.[8]

Age appears to be a predictor of injuries as well; older people experience higher injury rates. However, age it is ***not*** a good predictor of injuries among experienced, well-trained athletes.[8] So, once again, conditioning is important in injury prevention.

Stretching Rules:

1. In all cases, never stretch with a partner who is not a professional therapist. The partner cannot judge the depth of the stretch you are feeling and by the time you express discomfort, it may be too late and injury may have occurred.[10]
2. If you are an adult and you have never been able to do the splits or touch your toes, you probably never will be able to do these. If you try, you will most likely injure yourself.[10] Short ligaments reduce your flexibility. Stretching ligaments more than 6% beyond their normal length results in tears.[10] Stretching ligaments also destabilizes joints and may cause osteoarthritis.[10]
3. Do not force the stretch beyond the point where you can still tense the stretched muscles.[10] Forced stretching can damage muscles and even the capsule and ligaments of joints.
4. Never do ballistic stretches (bobbing, bouncing). This can result in immediate or residual pain resulting from injury to the soft tissue.[8,10]

The Bottom Line:

1. Skip stretching before exercise.
2. Increase your level of fitness to reduce DOMS and reduce the risk of injury.
3. Warm up for at least 10 minutes including exercises that mimic the upcoming workout or sport.
4. If you want to stretch, save it for your post-workout routine or engage in a regular program of stretching such as yoga or pilates.
5. When possible, engage in pandiculation/SYS after periods of inactivity.
6. When experiencing tight muscles, consider using the principles of Hanna Somatics or PNF. Contract tight muscles first and then gently stretch them which will result in a greater increase in range of motion.

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