Stretching the Truth

Stretching is good for us, right? Well, yes and no! It turns out that you have to do the right kind of stretching for the right duration at the right time according to what activity you are about to do. This article makes sense of the confusing mass of literature about stretching and will allow you to give individually tailored, sport-specific advice to your clients about how to get the benefits of stretching while avoiding the potential decrease in power output. This is not only crucial for the professional athlete where marginal gains can make all the difference, but is also useful for amateurs looking for improvements too. Read this article online https://spxj.nl/3zCnHnK

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A commonly held belief, by both professionals and the public, is that static stretching (StS) plays an important role in injury prevention and improving athletic performance (1). It is common practice therefore for athletes of all levels, both recreational and professional, to include StS in their routine. This may be during a 'warm-up' before a game or run, at the end of a run or activity, or as part of a strength training or rehabilitation programme. The physical practice of StS involves lengthening a muscle to a point where gentle tension is felt and that position is held, typically, for a minimum of 20–30 seconds (s; or longer) per stretch (2). Current research evidence, however, reports that this belief is, in fact, incorrect (3,4*).

Historically, until the 1990s, it was believed that StS promoted flexibility and improved athletic performance (5). This was mainly based on the thought that greater range of motion (ROM) reduced resistance to movement and improved movement economy (5). Passive and active stretching techniques have been shown to increase both chronic and acute ROM. In the past, StS was also promoted for longer durations – holding an individual stretch repeatedly for more than 30s to allow for viscoelastic (muscle) 'creep' (6). However, since the early 2000s, research had started discussing the potential harmful effects of StS on strength and power-related activities (5,7). Acute ROM improvements can be countered by decreases in muscle performance, primarily after prolonged StS and proprioceptive neuromuscular facilitation (PNF) techniques when not incorporated into a full warm-up procedure (8*). As a result, it has been widely recommended to avoid performing prolonged StS before strength and power-related tasks, with dynamic stretching (DS) exercises being favoured instead (5). DS (and even to an extent ballistic) stretching techniques typically induce either an increase or no change in muscular force and power (8*).

Subsequent to this, new evidence challenged the view that StS was taboo and should not be conducted before activity or performance. Findings by Behm et al. and Kay et al. showed that short-duration acute StS (≤60s) had trivial (almost negligible) negative effects on strength and power as opposed to prolonged StS (>60 seconds) (9*,10*). In addition to this, recent findings demonstrated that when short-duration StS was included in a full warm-up routine, it did not impair subsequent strength and power performances (11*,12). For clarity, the stretch times discussed in research are total time per muscle group – so a total of less than 60s of stretching does not seem to be detrimental, but greater than 60s does. Thus, 3×30-second stretches of the quadriceps equates to 90s, potentially inducing deficits in muscle strength and power according to the research (9*,10*).

It seems that the contradictory and constantly changing reports with regard to the benefits or detriment of StS may cause confusion, particularly with coaches, practitioners and in the messages being disseminated to the public. This article aims to inform the reader to better understand when, why and for how long to use StS in the athletic and general population.

Stretching Controversies and Clarity

Following the evidence for stretch-induced performance decrements, there has been a paradigm shift on optimal stretching routines within a warm-up (13*). Impaired power and force performance subsequent to StS lead many people to incorporate DS into their routines. Owing to the closer similarity to movements that occur during subsequent exercises, DS would be expected to be superior to StS (13*). However, the evidence is not unanimous. Studies implementing DS have reported both facilitation of power, sprint and jump performance as well as no adverse effect [see Samson et al. and references therein (13*)]. Much of the research would suggest that combining StS and DS during warm-up may attenuate the harmful effects of StS alone (8*). Granted, there are discrepancies as to whether DS improves or has no effect on performance (13*); however, currently there are no studies to report dynamic stretch-induced impairments to subsequent performance.

After reading the information

SINCE THE EARLY 2000s, RESEARCH HAS STARTED DISCUSSING THE POTENTIAL HARMFUL EFFECTS OF STATIC STRETCHING ON STRENGTH AND POWER-RELATED ACTIVITIES

above, you may ask yourself why then even consider including StS in a warm-up if DS does the job? There are a number of sports where improved static flexibility, essentially joint ROM, could enhance performance. Gymnastics, a soccer or ice hockey goalie, synchronised swimming, martial arts, wrestling, ballet and figure skating are just a few examples where pronounced static ROM is a necessity. DS has shown to increase static flexibility, but not to the same extent as StS. Hence, it may be important to include StS in certain sport-specific situations or with certain individuals. Timing when to do the StS must also be considered so as not to negatively impact training or performance.

StS performed before strength and power activities has been shown to have negative effects. But what about endurance events such as running? Running is one of the most popular activities worldwide and is the base of many people's physical activity routines. So should they be stretching before running? Performing StS before distance running (a mile or more) has shown to reduce running performance (14*). A possible biomechanical explanation for this was a more pronounced ground contact time. StS before running resulted in a higher ground contact time caused by a "decrease in the efficiency to transfer previously stored energy" (essentially an adverse effect on the stretch-shortening cycle) and therefore a decrease in running performance (14*). StS exercises performed before running showed a decrease in jump height and isometric strength, but no difference in running economy (RE) (which includes oxygen uptake, minute ventilation, energy expenditure, respiratory exchange ratio) or heart rate response (15). Similar studies have shown StS has no effect on RE

Figure 1: Myth: static stretching reduces injury risk in runners Alexander JLN, Barton CJ, Willy RW. Infographic running myth: static stretching reduces injury risk in runners. British Journal of Sports Medicine 2020;54(17):1058–1059 (17)

●● STATIC STRETCHING IN A WARM-UP CAN BE USEFUL FOR SPORTS WHERE PRONOUNCED JOINT ROM IS REQUIRED ●●

but did affect jump performance (13*). Yamaguchi et al. applied a DS intervention on running performance in male middle- or long-distance runners (16). The study included five exercises performed 10 times, as fast as possible, and showed no changes in RE. However, the time to exhaustion and running distance were prolonged in the DS group compared to those in the non-stretching control.

Figure 1 shows a handy downloadable infographic by Alexander et al. that nicely summarises the myths around StS, what the evidence does show and what runners could do instead of StS (17).

Therefore, if the goal is to increase running performance, DS should be considered but not StS alone (14*). Behm et al. found that even though rigorous StS is likely to have no beneficial effect on running performance, a 54% reduction in acute muscle injuries was reported with stretching (9*). Therefore, StS, especially if applied for short durations and in combination with additional warm-up exercises (discussed below), still has overall positive effects for an athlete (9*,18*).

Stretching Public Opinion

The benefits of stretching have traditionally been well documented and as such is a very popular exercise modality. It is used for general health, recreation and performance. Stretching may be implemented into exercise programmes for therapeutic reasons (prehabilitation or rehabilitation), in different diseases such as rheumatoid arthritis, or to correct muscle imbalance. Thousands of research papers have been published to determine the acute or chronic effects of stretching, to find the optimal techniques, duration and intensity. Briefly, stretching exercises are used as pre- and/or post-activity to increase joint ROM, health, muscle performance, to promote recovery, or to reduce activity-related injury risks (8*,19*,20*).

Quite often sport or physical activities are not guided or supervised by a professional, and therefore identifying an individual's stretching practices is of paramount importance to give adequate practical guidelines for performance as well as for health benefits.

A recent survey investigated the stretching habits of over 3000 active individuals who were involved in regular physical activity, across a range of sports, and at varying levels of competition (20*).

Briefly, the results of that study showed the following outcomes.

1. General Habits and Reasons

- Individuals mostly indicated it was a necessity to stretch because of muscle pain (59.6%), muscle stiffness (59.0%), or simply for wellness (60.0%).
- Stretching was a necessity after training or competition (77.9%) or after a series of training or competition (32.6%).
- People who did not conduct stretching indicated it was because of a lack of motivation (26%), time (22%), knowledge (why and how to do, 20% and 13.7%, respectively), lack of supervision (10.3%), or poor efficiency (6.4%).
- Those performing stretching mostly reported it was for recovery, to gain flexibility, for injury prevention and performance.
- Stretching was mostly performed after training.
- National/international level individuals mostly practised stretching on a daily basis.

2. Education and Supervision

- Most respondents had not received education, but obtained information (~60%) while reading books (45.0%), discussing with others (47.0%), or from the internet (34.5%).
- Two-thirds of the individuals were not supervised while stretching.
- Stretching was mostly supervised by coaches (95.3%), health professionals (34.5%) and other athletes (24.7%) – this pertained to national and international level athletes.

3. Stretching Type

- Both men and women, as well as recreational up to international level athletes reported the most common type of stretching was static, followed by passive, then active and dynamic.

When considering the opinions of the general public it is easy to see that there are some misapprehensions regarding stretching. It was felt that stretching was necessary to improve flexibility and wellness. Yes, stretching can improve the joint ROM but this must not be confused with a person's sense of muscle stiffness and using stretching to relieve this, which potentially may have negative effects on their exercise performance (discussed in further detail below). Stretching has been used in office-based settings and other studies to relieve tension and promote wellness and quality of life. Certainly, stretching is only one part of an exercise programme that should include other components such as strength or cardiovascular activity. As a result of the perceived negative effects of stretching, a recent paper suggested that flexibility should be 'retired' from fitness programmes, partly to save time and to emphasise the other components that could have more robust benefits for health and performance (21).

Nearly 75% of individuals performed stretching after activity and reported using it for recovery and to reduce pain or muscle soreness. There may be some evidence of positive effects of stretching on pain sensitivity and pain inhibitory systems (22). There is, however, no clear evidence to demonstrate the positive effects of stretching on recovery. Some studies have shown small to moderate effects on perceived muscle soreness (delayed onset muscle soreness or DOMS) following eccentric exercises (23); however, in contrast, numerous studies have shown stretching to be ineffective in decreasing muscle pain and cramping. Stretching performed at intervals, for example between sets, could potentially have detrimental effects because of the negative effects on the neuromuscular system in generating torque (20*).

Indeed, although injury prevention was often cited (in nearly 50% of responders) to justify the use of stretching during pre-activity warm-up routines, the effects were generally unclear and with only limited beneficial results. This agrees with the current literature where a direct link between flexibility and injury prevention is unclear (9*,24*,25*).

Individuals believe they can improve performance and ROM as well as prevent injury by stretching during the warm-up (before training or competition). The question of the effectiveness of stretching for performance is currently widely documented. As stated earlier, research has shown that StS before activity may have a detrimental effect on reduced muscle strength and power (5,7). It is now generally agreed that short-duration stretching exercises could be performed within a comprehensive warm-up procedure (5,9*,10*,12,19*) and that DS (slow conducted dynamic stretch) is also recommended (7).

A recent survey of 138 coaches involved in 21 different sporting disciplines had different views on stretching (26*). Some reported not doing any stretching with their athletes based on time restrictions and "leaving conditioning up to the athlete". The majority of coaches (86%) used StS over DS in their warm-up and cool-down routines. During these, the static stretches were held on average for 20s. Coaches reported using stretching to reduce injury risk, increase flexibility, and (specifically for DS) to improve performance. The study found that there may be gaps between the evidence of stretching and its practice, and that coaches may not have the means to interpret the evidence and convert that into practice, so future focus on how this can be achieved is crucial (26*).

Elite competitive individuals appeared better supervised and conducted slightly more adequate and evidence-based stretching sessions than the recreational athlete (20*). This is not surprising given that athletes at that level work closely with coaches and physical therapists. In general, however, education, instruction and supervision should be developed to favour appropriate stretching intensity, technique and positioning. Indeed, from the current survey, supervision appeared poorly provided, as did the understanding of when or why we stretch (20*), with the majority of people believing in essentially only one type of stretch – static. Surely it is our responsibility to educate them about the current science, ensuring best practice of timing and duration to maximise benefits.

Stretching Type

1. Static Stretching – Passive and Active

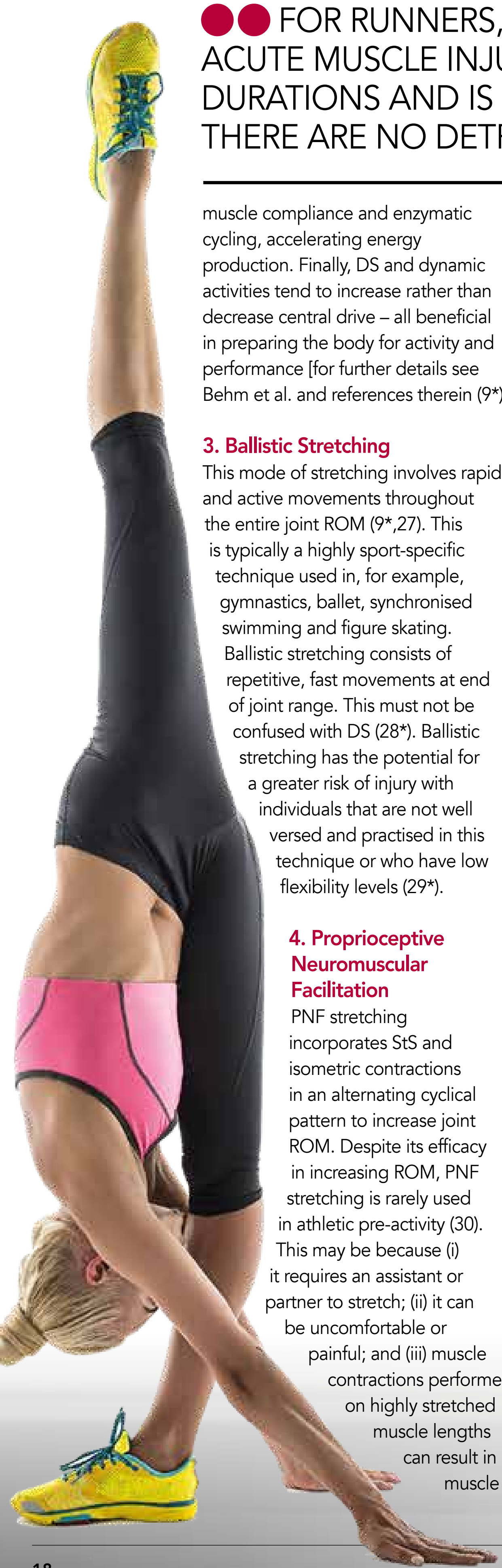
StS consists of lengthening the muscle towards the end of ROM until experiencing near or maximal point of discomfort and then holding this position for an extended period of time (15–90s) with no additional forces applied (8*,9*,10*). Passive StS is defined as "elastic structures being stretched by an external force with no rate change for a period of time" (8*). Active StS is similar except the individual exerts their own force, either through contraction of an antagonist muscle, or use of their arms to pull their limbs or use body mass to help elongate musculotendinous tissues (8*). This technique has been incorporated as one of the most popular warm-up routines and/or can be performed individually to improve joint flexibility.

2. Dynamic Stretching

This form of stretching involves performing larger movements over a full or nearly full ROM. These movements should be performed under controlled conditions: moderate to relatively rapid angular velocities (7,9*,27). There must, however, be an emphasis on controlled motion. As already mentioned, although StS leads to improvements in joint ROM the decrements in muscular performance and muscle force have resulted in many coaches, athletes and medical professionals opting to prescribe active DS rather than StS. Studies have shown that the ROM improvements with DS are similar to that of StS but without the negative effects on muscle performance (7,8*,9*,10*,19*).

This has resulted in DS experiencing a flood of popularity, especially with athletic warm-ups that don't specifically require high levels of flexibility as their primary training focus. DS may be considered preferable over StS in preparation for physical activity, as it more closely mimics the exercise movement patterns. DS can elevate core-temperature which may increase nerve conduction velocity,

●● FOR RUNNERS, STATIC STRETCHING CAN HELP REDUCE ACUTE MUSCLE INJURIES AND IF IT IS USED FOR SHORT DURATIONS AND IS COMBINED WITH ACTIVE WARM-UP ACTIVITIES, THERE ARE NO DETRIMENTAL EFFECTS ON PERFORMANCE ●●



muscle compliance and enzymatic cycling, accelerating energy production. Finally, DS and dynamic activities tend to increase rather than decrease central drive – all beneficial in preparing the body for activity and performance [for further details see Behm et al. and references therein (9*)].

3. Ballistic Stretching

This mode of stretching involves rapid and active movements throughout the entire joint ROM (9*,27). This is typically a highly sport-specific technique used in, for example, gymnastics, ballet, synchronised swimming and figure skating. Ballistic stretching consists of repetitive, fast movements at end of joint range. This must not be confused with DS (28*). Ballistic stretching has the potential for a greater risk of injury with individuals that are not well versed and practised in this technique or who have low flexibility levels (29*).

4. Proprioceptive Neuromuscular Facilitation

PNF stretching incorporates StS and isometric contractions in an alternating cyclical pattern to increase joint ROM. Despite its efficacy in increasing ROM, PNF stretching is rarely used in athletic pre-activity (30). This may be because (i) it requires an assistant or partner to stretch; (ii) it can be uncomfortable or painful; and (iii) muscle contractions performed on highly stretched muscle lengths can result in muscle damage and speculatively increase injury risk (9*). PNF stretching still, however, remains an effective practice.

Although StS, DS and PNF all significantly increase passive ROM (30), whether one technique is superior to the other in providing greater acute ROM benefits is disputed. It is not possible to rank the different forms of stretching in hierarchy; all are effective when performed at the right time, for the right duration and within the right context relevant to the athlete and their activity.

Stretching Duration

Several original and review articles [see Behm et al. (9*) and references therein] report a dose–response relationship, with more than 60s of StS being more likely to result in performance deficits; however, shorter duration StS has little effect (10*,31). Research by Palmer et al. examined the acute effects of different StS durations (30, 60 and 120s) of the hamstrings on maximal strength and power (32). Their results showed significant declines in muscle power post-StS for 120s but not after 30 and 60s (32). Interestingly research has shown that prolonged (120s) hamstring unilateral StS stretching revealed a significant performance decline in knee extensor strength after StS in both the ipsilateral (Δ, −8%) and contralateral (Δ, −4.2%) leg (33). The change in strength (Δ) is negative for a decrease in strength and positive for an increase. The most recent literature reviews have concluded that more than 60s of StS per muscle group substantially inhibits strength and power measures (Δ, −4.6%). Whereas StS totalling 60s or less has proved to be less harmful (Δ, −1.1%) (9*,10*). The negative acute effects of StS have to be interpreted from a dose–response perspective, and not a blanket approach to avoid the stretching technique altogether. In other words, StS conducted over short durations (≤60s per muscle group) can be recommended while long-duration (>60s per muscle group) StS has negative effects on strength and power performances. If followed by an active dynamic warm-up or sufficient rest time before performance/racing/activity then these negative effects (regardless of duration) become negligible (discussed in more detail below).

The likely effect on performance even after longer duration StS is moderate (<5% negative change in performance). However small, in many contexts these performance losses may be very relevant to an athlete, specifically in sports involving speed, power and strength: for example elite sprinting, long and high jumps, throwing (discus, javelin, shot put), etc. (9*).

The underlying mechanisms responsible for long-duration StS-induced impairments in strength and power activities may not be fully understood. Some research suggests an increased compliance of the musculotendinous unit (MTU) that lowers MTU stiffness combined with lower motor unit activation (19*). Less is known about the potential physiological mechanisms underpinning short-duration StS when performed as a single-mode treatment or when integrated into a full warm-up routine. Studies have shown that the rate of electromyography rise (moderated by factors such as early recruitment of motor units and discharge rates) during short-duration (≤60s) StS were not significantly affected (32). Unchanged or minor reductions in MTU stiffness are associated with short-duration (<60s) StS, which could contribute to the maintenance of muscle capacity to generate torque (32). Research by Kay et al. revealed that short-duration StS reduced muscle but not tendon stiffness; and thus concluded that stiffness alterations resulting from short-duration StS could be tissue specific (34*).

There is limited literature investigating the 'non-local' effects of prolonged StS. However, research revealed that both the stretched and contralateral (ie. non-stretched) limbs of young adults demonstrate small-magnitude force deficits (35). However, the frequency of studies with these effects were similar with three measures demonstrating deficits, and four measures showing trivial changes. These results [and others highlighted in Behm et al. (35)] suggest the possible global (non-local) effects of prolonged StS. More research is necessary to investigate the effects of lower intensity stretching, upper versus lower body stretching, different age groups, incorporating full warm-ups, and identify predominant mechanisms among others in this global effect (35).

Stretching Intensity

StS is commonly used as part of a warm-up routine in order to increase ROM and potentially prevent injuries. A sufficient level of MTU compliance is needed for sports that use a stretch-shortening cycle. This is to ensure the MTU works effectively in storing and releasing high amounts of elastic energy. If a MTU has insufficient compliance the demands in energy absorption and release may exceed the capacity of the MTU, which may increase the risk of injuries. In the event of insufficient MTU compliance, the demands in energy absorption and release may rapidly exceed the capacity of the MTU, which may cause a higher risk of injuries (36,37). Past studies [cited within Behm et al. (9*) and Takeuchi et al. (38*)] have reported that StS may decrease MTU stiffness, effectively implying therefore that StS used as part of a warm-up routine decreases MTU stiffness and could lead to the prevention of injuries. Both the duration and intensity of the StS will affect MTU stiffness (39*,40*).

StS at high intensity can be accompanied by moderate-to-severe pain (38*). On an 11-point numerical rating scale (NRS) ranging from 0 (no pain) to 10 (worst imaginable pain), studies indicated that the median NRS for pain during StS at high intensity was 8 (40*). However, NRS immediately after stretching and 24h after the stretching were both level 0 (40*).

Data has suggested, however, that high-intensity StS for 20s used as part of a warm-up routine does not change MTU stiffness and may therefore not have an effect on injury risk reduction (40*,41*). Kataura et al. showed that long-duration (180s) StS at greater intensity (80, 100 and 120% of maximum tolerable intensity without pain) is more effective for increasing ROM and decreasing passive MTU stiffness (42*). However, two issues exist with this method. Firstly, as has been discussed, long-duration StS of more than 60s results in strength and power deficits which can affect performance. Secondly, many athletes practise within a limited time, it is difficult to perform StS for more than 180s for each muscle. So, if the potential benefits to reduce injury risk come from long-duration and high-intensity StS, how can we get the same result of decreasing MTU stiffness in under 60s to avoid the performance deficits?

Peak torque, an indicator of muscle strength, decreased after high-intensity StS for 10s, although there was no further change after more than 15s of high-intensity StS (38*). The decrement in muscle strength following StS is restored within 10min (43*). In addition to this, performing active warm-up and dynamic activities following StS can mitigate the negative effects of high-intensity StS on strength and power (discussed in more detail below) (13*,19*,23). Athletes who elect to stretch statically, need to choose the duration, intensity and timing of StS taking into account their subsequent activities; be it active warm-up or directly into performance. If great muscle strength activity is required immediately after high-intensity StS (without any activities) more than 15s of stretching should be used to maximise decreases in MTU stiffness. If athletes have more than 10min before performance or participate in an active warm-up following high-intensity StS, then 10s of high-intensity StS will be effective and minimise stretching pain (38*).

Stretching Combined with Active Warm-Up

Research by Reid et al. investigated the effects of StS durations (30s, 60s, 120s) as part of a full warm-up which included DS and dynamic activities (12). Strength and power measures were significantly affected by prolonged StS (120s) even when incorporated into an active warm-up. However, despite the StS-induced neuromuscular activation impairments, muscle strength and power seemed not to be simultaneously affected by short-duration StS (30s, 60s) with active warm-up (12). Although 120s StS per muscle increased ROM, even within a comprehensive warm-up routine, it elicited notable performance decrements. However, moderate duration StS with active warm-up seemed to improve ROM while having either negligible or beneficial (but not detrimental) effects on specific aspects of athletic performance (12).

Physiologically it seems therefore that 'something' during active warm-up counters the negative effects of the central neuromuscular impairment of StS. During

●● IT IS NOW GENERALLY AGREED THAT SHORT-DURATION STRETCHING EXERCISES COULD BE PERFORMED WITHIN A COMPREHENSIVE WARM-UP PROCEDURE AND THAT SLOW CONDUCTED DYNAMIC STRETCHING IS ALSO RECOMMENDED ●●

a dynamic warm-up muscles are stretched and contracted actively through a variety of activities increasing body and muscle temperature (19*). It has been shown that increased muscle temperature is accompanied by increased muscle fibre conduction velocity and improved binding of contractile proteins actin and myosin (19*). A large positive association between muscle temperature and power output exists: a 1°C increase in muscle temperature results in a 2–5% improvement in muscle power performance (44*). A raised muscle temperature can also alter force-velocity, improving performance (19*). A conclusion made by Behm et al. was that although prolonged (>60s per muscle group) StS and PNF stretching performed in isolation typically induce performance impairments, there is little evidence that these deficits linger when the stretching is combined with a full active warm-up (8*,9*).

Post-stretching dynamic activities might be a possible approach to decrease the likelihood of a drop in performance following StS exercise. Studies that include post-StS dynamic activity do not report significant impairments (11*,12,13*). Samson et al. compared the effects of specific active warm-ups with StS or DS on 'springiness' exercises (for example jump height or 20m sprint time) (13*). The stretching was performed for 3×30s for each muscle, resulting in a total stretching time of 90s. When a sport-specific warm-up was included following StS and DS, the 20m sprint time showed an improvement compared to the StS and DS groups without an active warm-up component. Additionally, subjects that performed either a 5s StS, a 30s StS, or a five-repetition DS for each muscle [including both a low-intensity (pre-stretching) and a high-intensity (post-stretching) warm-up] showed no deficit in 'springiness' tasks (11*).

What is more, Reid et al. showed that StS (30 or 60s) when combined with a post-stretching comprehensive warm-up increased vertical jump performance and did not change force production (12). In contrast, subjects that performed StS for 120s (with the same comprehensive warm-up) showed no change in vertical jump performance. Combining these results shows that active warm-up performed after StS and DS of up to 90s increased 'springiness' performance, whereas a longer stretching period (120s) produced either a negative effect or has no effect (12). Several authors [cited in Behm et al. (9*)] have suggested including post-stretching dynamic activities in the warm-up regimes of athletes, counteracting any detrimental effects on performance by StS alone.

Conclusion

Flexibility has often been considered a major component in physical fitness. Flexibility has little predictive efficacy with health and performance outcomes (for example mortality, falls and occupational performance) in apparently healthy individuals, particularly when viewed in light of the other major components of fitness (such as body composition, cardiovascular endurance, muscle endurance, muscle strength) (21). If flexibility requires improvement, it does not demand a prescription for stretching in most people. Flexibility can be maintained or improved by exercise modalities that cause more robust health benefits than stretching alone, for example resistance training (21). The general population are often looking to simplify their fitness routines, to save time and resources. One author's opinion is that de-emphasising stretching (on the back of its current 'bad rap') in exercise prescription will ensure it does not negatively impact other exercise or take away time that could be allocated to training activities that have more robust health and performance benefits (21).

Yes, the literature on StS has been subject to controversial debate over the past decades. Figure 1 'Timeline of the controversial mindset about the acute effects of static stretching (StS) on strength and power performances' from Chaabene et al. provides a good summary of the previous and current available evidence and practical recommendations on StS (https://bit.ly/3sgwc51) (19*). There is strong evidence now suggesting that StS causes only trivial negative effects on subsequent strength and power performances if the accumulated duration per muscle group does not exceed 60s. Consequently, we as practitioners should update these previous beliefs on the harmful effects of StS and rather apply greater specificity in stretching instruction to achieve optimal outcomes.

In the research laboratory setting, where post-stretching testing is performed almost immediately (on average 3–5min), StS-, DS- and PNF-induced performance changes were typically small to moderate: –3.7, +1.3 and –4.4%, respectively (9*). An initial assumption, based on the overall negative results that StS and PNF have on performance, is not to prescribe them and rather to advise the use of DS to increase ROM. However, the reality is that stretching-to-performance durations are often more than 10min in many circumstances (for example sports competitions). In studies that conducted tests more than 10min after stretching, performance changes were typically statistically trivial or negligible unless extreme stretch protocols were used (9*,43*).

StS impairments were more substantial with more than 60s (–4.6%) versus 60s or less (–1.1%) of stretching duration per muscle group. It should be considered that for certain athletes and sporting disciplines requiring greater ROM increases, longer duration StS and PNF may be performed well before (for example >10min) the task/performance to allow the negative effects to resolve. However, DS may be performed closer to the performance.

Considering the application of stretching in sports practice, further conditions have to be considered to give recommendations. First of all, post-stretching dynamic activities or active warm-up must be implemented to decrease the likelihood of performance deficits (9*,14*). Secondly, targeted stretching of only the muscle groups for which greater compliance is beneficial for the athletes activity should be applied (14*).

The few studies that included post-stretching (StS up to 90s) dynamic activity did not show substantial negative effects on performance (12,13*). All forms of muscle stretching have been shown to provide significant acute ROM benefit. StS and PNF show no overall effect on all-cause injury or overuse injuries, but there may be a benefit in reducing acute muscle injuries with running, sprinting, or other repetitive contractions (9*). There is conflicting evidence as to whether stretching in any form before exercise can reduce exercise-induced muscle soreness (DOMS) (9*).

Stretching in some form appears to be of greater benefit than cost (in terms of performance, ROM and injury risk); however, the type of stretching chosen, and the make-up of the stretch routine (duration, intensity, inclusion of active dynamic warm-up and timing to event/performance) needs to be carefully considered. In high-performance sports, minimal performance differences can have a major impact on athletes' success in competition. Rather than prescribing a generic stretching routine, the context of the individual's needs and their sporting activity must to be considered to ensure peak benefit.

KEY POINTS

- The literature on static stretching (StS) has been subject to controversial debate over the past decades.
- Evidence suggested that prolonged duration StS caused decrements in performance of power and strength activities.
- StS impairments on performance were more substantial when performed for ≥60s total per muscle group.
- Research now shows that StS performed for <60s total per muscle group resulted in trivial, almost negligible effects on muscle performance.
- Post-stretching (short or long-duration StS) dynamic activities in an athlete's warm-up regime counteract any detrimental effects on performance created by stretching alone.
- Any negative performance changes elicited by short or long-duration StS are typically statistically trivial or negligible after 10min of elapsed time to performance (unless extreme stretch protocols are used).
- StS used as part of a warm-up routine decreases musculotendinous unit (MTU) stiffness and could lead to the prevention of injuries.
- Instead of long-duration (180s) StS, greater intensity StS (pain rating scale of 8–9) for shorter duration (10s per stretch) may elicit a decrease in (MTU) stiffness without detrimental performance effects.
- Dynamic stretching (DS) increases range of motion (ROM) and does not elicit negative performance effects like StS and proprioceptive neuromuscular facilitation (PNF) stretching.
- StS and PNF are most effective in increasing ROM and should be considered on an individual athlete and sport-specific basis.
- Performing short-duration StS combined with an active warm-up and allowing time between stretching and performance negates any negative performance effects of stretching alone

References

Owing to space limitations in the print version, the references that accompany this article are available at the following link at the following link https://spxj.nl/3zCnHnK

RELATED CONTENT

- Fascial Stretch Therapy™ for the Lower Body [Article] https://bit.ly/2GTUPB3
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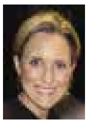
DISCUSSIONS

- What is your current stretching prescription, especially in athletes?
- Would you consider prescribing higher intensity stretching over a shorter period to achieve the same results in decreasing MTU stiffness thereby increasing ROM and reducing injury risk?
- How do you plan to move forward incorporating StS, PNF and DS in individuals with different sporting demands?



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Stretching the Truth

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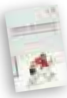

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