Origins of the myths

Stretching and prevention of soreness
The origins of these myths are obscure. In the 1960s, Herbert de Vries, an exercise physiologist from the University of Southern California, popularised the view that the muscle soreness commonly experienced in the days after exercise was due to muscle spasm [1]. He believed that exercise caused painful muscle ischemia, which in turn caused a reflex tonic muscle contraction, causing more pain, and so on. Today this is sometimes called the ‘pain-spasm-pain cycle’. According to de Vries, muscle stretching after exercise is beneficial because it reflexly inhibits muscle spasm, interrupting the pain-spasm-pain cycle. He conducted a number of studies which purported to show that experimentally induced soreness of elbow flexor muscles was accompanied by an increase in electromyographic activity, and that stretching reduced muscle activity. These ideas encouraged the practice of stretching after exercise, but they have now been discredited. Muscle soreness is now known to be caused by damage to sarcomeres or the sarcolemma [2], and it has been shown that muscle soreness is not associated with tonic muscle activity [3].

Stretching and prevention of injury
The rationale behind the effect of stretching on risk of injury is more apparent. Acute soft tissues injuries occur when tissues such as muscles are subject to exces-
were young healthy adults. Three trials examined the effects of stretching before exercise and seven trials investigated the effects of stretching after exercise. Two trials, both of stretching after exercise, involved repeated stretching sessions at intervals of greater than two hours. The duration of stretching applied in a single session ranged from 40 to 600 seconds. There was a high degree of consistency across trials in the estimates of effects of stretching: all trials showed near-zero effects of stretching. The pooled estimate showed that pre-exercise stretching reduced soreness one day after exercise by, on average, 0.5 points on a 100-point scale (95% CI -11.3 to 10.3; 3 trials). This result is shown graphically in figure 1. Post-exercise stretching reduced soreness one day after exercise by, on average, 1.0 point on a 100-point scale (95% CI -6.9 to 4.8; 4 trials). Similar effects were evident between half a day and three days after exercise. This evidence, derived from mainly laboratory-based trials of stretching, indicates that muscle stretching does not appreciably reduce delayed-onset muscle soreness in young healthy adults.

**Risk of injury**

Two large randomised trials have examined the effects of stretching before exercising on the risk of injury in military recruits undergoing 12 weeks of initial training [7, 8]. The first study investigated effects of supervised stretching of calf muscles before exercising (two stretches of soleus and gastrocnemius muscles for 20 seconds on each limb, total stretch time 160 seconds) on risk of six specific leg injuries (lesions of the Achilles tendon, lateral ankle sprains, stress fractures to the foot and tibia, periostitis, or anterior tibial compartment syndrome). The second study investigated effects of supervised stretching of six muscle groups in the lower limbs before exercising (one 20-second stretch to each muscle group on each limb, total stretch time 240 seconds) on risk of soft tissue injury, bone injury, and all injury. Recruits were considered to have sustained an injury if they were unable to return to full duties without signs or symptoms in three days. In both studies, subjects in both stretch and control groups also performed gentle warm up exercises. The two studies yielded similar, statistically non-significant and small estimates of risk reduction (relative risk reductions of 8% and 5%; figure 2). Data from the two studies (2630 subjects, 65 platoons) were combined [9]. The combined estimate was that stretching reduced injury risk by just 5% (95% 22% to -16%, p = 0.61); this effect was statistically non-significant. We have shown that this effect is equivalent to the average subject stretching for 23 years to prevent one injury [9]. Together these studies suggest stretching does not appreciably reduce muscle soreness or injury risk.

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**Figure 1.** Forest plot summarising findings of seven studies of the effects of stretching on muscle soreness one day after exercise. Each row of the forest plot illustrates the size of the effect of stretching (estimated reduction in muscle soreness, on a 100-point scale) reported in one study (squares are mean effects and bars are 95% confidence intervals). All seven studies found that the effect of stretching was nearly zero. The diamond represents the pooled effect estimated with all seven studies. Figure re-drawn from [6].

**Figure 2.** Data from two randomised trials [7, 8] of the effects of stretching on injury risk in army recruits undergoing military training. The survival curves show how the probability of remaining injury free decreases (i.e. risk of injury increases) with time in groups of army recruits who stretched (S) or did not stretch (C) prior to physical activity. In both studies the rates of injury in the stretch and control groups were very similar. Figure re-drawn from [9].
Implications for practice

The implications for practice appear quite straightforward. Most people will not consider the effects of stretching before or after physical activity on muscle soreness or injury risk to be of sufficient magnitude to make stretching worthwhile. Consequently physiotherapists should not generally recommend that people stretch before or after physical activity, at least if the aim is to reduce soreness or risk of injury.

Of course some people stretch for reasons other than to reduce soreness or risk of injury. Some people stretch because they believe that stretching enhances performance in physical activities. The available evidence concerning the effects of stretching on performance is ambivalent. Others stretch because stretching makes them feel looser or more prepared to exercise. Individuals can make their own judgements about whether stretching makes them feel looser or more prepared for exercise.

Note that the studies considered here have examined the effects of stretching, not the effects of warm-up. Warm-up routines typically include stretches, but almost always involve other components, such as light exercise. There is strong evidence that, in contrast to stretching, properly designed warm-up programs can reduce risk of injury [11] and soreness [12].

REFERENCES