Effects of stretching before and after exercising on muscle soreness and risk of injury: systematic review

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Authors' objectives
To determine the effects of stretching before and after exercising on delayed onset muscle soreness after exercise, the risk of injury, and athletic performance.

Searching
MEDLINE from 1966 to February 2000, EMBASE from 1988 to February 2000, CINAHL from 1982 to January 2000, SPORTDiscuss from 1949 to December 1999, and PEDro up to February 2000, were searched for studies in the English language. The search terms included: 'stretch$.mp'; 'flexib$.mp'; '( warmup or warm-up or warm up or cooldown or cool-down or cool down).mp'; 'athletic injuries.sh'; 'sore$ adj3 musc$.mp'; 'sports.sh'; 'exercise.sh'; 'exertion.sh'. Further details of the search are provided on the BMJ website. See Web Address at end of abstract. The bibliographies of studies identified by the electronic searches were then searched recursively until no more studies were identified.

Study selection
Study designs of evaluations included in the review
Any randomised or quasi-randomised study employing an intervention and a control group was eligible for inclusion in the review.

Specific interventions included in the review
Any stretching technique conducted immediately before or after exercise for the purpose of reducing delayed onset muscle soreness, or risk of injury, or to improve athletic or sporting performance, was eligible for inclusion in the review. In studies assessing delayed onset muscle soreness, the total stretch time per session varied from 300 to 600 seconds, with the exception of one study in which it was only 80 seconds. The control groups did not engage in stretching. For risk of injury, the effect of stretching before exercising on the risk of specific or all leg injuries was evaluated. The control groups did not engage in stretching.

Participants included in the review
Any group undertaking physical exercise who engaged in stretching techniques was eligible for inclusion in the review. In two studies, the participants were new military recruits who were undergoing 12 weeks of initial training.

Outcomes assessed in the review
Delayed onset muscle soreness (measured on various numerical scales) at 24, 48 and 72 hours following exercise, was assessed as a continuous outcome in the review. The risk of injury was also assessed in the review; in one study, injury was defined as the participant being unable to return to full duties without signs or symptoms within 3 days. Athletic performance was an outcome which was looked for, but not found, in the included studies.

How were decisions on the relevance of primary studies made?
One reviewer screened the search results for potentially eligible studies, and any uncertainties were resolved by discussion with a second reviewer.

Assessment of study quality
The validity of the primary studies was assessed with the PEDro scale (see Other Publications of Related Interest nos.1-2). The criteria included: specification of eligibility criteria; randomisation; concealment of allocation; baseline similarity; blinding; completeness of follow-up; intention to treat analysis; statistical analysis; and measures of variance. Only studies scoring at least 3 out of a maximum of 10 were included in the review. Methodological quality was assessed independently by two assessors, and any disagreements were resolved by a third independent assessor.
Data extraction
The authors do not state how the data were extracted for the review, or how many of the reviewers performed the data extraction.

Data were extracted on muscle soreness scores. These were measured as mm on a 100-mm visual analogue scale (VAS), where a negative value favours stretching, then converted into percentages of the maximum possible score (i.e. 100). For risk of injury, time to event data were obtained directly from the study authors and hazard ratios were calculated.

Methods of synthesis
How were the studies combined?
Studies were combined statistically in a meta-analysis. The meta-analysis of continuous outcomes (scores for muscle soreness) was performed using a fixed-effect model (see Other Publications of Related Interest no.3). As there was no evidence of heterogeneity in the outcomes of the studies, they were combined using stretching both before and after exercising in the meta-analysis. For risk of injury, the time to event data were combined in a pooled hazard ratio and survival curves were analysed with Cox regression.

How were differences between studies investigated?
Heterogeneity was investigated using the Q test. A sensitivity analysis was carried out to investigate the choice of threshold quality score and assumptions about correlations between repeated measures.

Results of the review
Nine studies were included in the review. Seven studies (6 publications) investigated the effect of stretching on delayed onset muscle soreness (n=224), of which only 5 (n=89) had sufficient data to be included in the meta-analysis. Two studies (n=2,631) investigated the effect of stretching on risk of injury.

Effect of stretching on delayed onset muscle soreness.
The pooled mean effects of stretching on muscle soreness (5 studies) were -0.9 mm (95% confidence interval, CI: -4.4, 2.6, p=0.70; n=77) at 24 hours after exercising, 0.3 mm (95% CI: -4.0, 4.5, p=0.45; n=77) at 48 hours, and -1.6 mm (95% CI: -5.9, 2.6, p=0.77; n=67) at 72 hours. The results, therefore, imply that stretching reduces soreness by less than 2 mm on a 100-mm scale at 72 hours post-exercise.

The sensitivity analysis indicated that the choice of threshold quality score and assumptions about correlations between repeated measures had little effect on the result.

Effect of stretching on risk of injury.
The two included studies yielded similar estimates of risk reduction; the hazard ratios were 0.92 (95% CI: 0.52, 1.61) and 0.95 (95% CI: 0.77, 1.18). The pooled data yielded a total of 181 injuries in stretch groups and 200 injuries in control groups. The survival curves for the stretch and control groups were similar. The pooled estimate of the hazard ratio for the influence of stretching was 0.95 (95% CI: 0.78, 1.16, p=0.61), with exercise reducing the risk of injury by a statistically non significant 5%.

Authors' conclusions
Stretching before and after exercising does not confer protection from muscle soreness, while stretching before exercise does not seem to confer a practically useful reduction in the risk of injury.

CRD commentary
The review question and the study selection criteria were stated clearly. The literature search seemed comprehensive, although the restriction to studies in English may mean that relevant material was missed. There was good information...
on the study selection and data extraction processes. The range of statistical tests employed for the data analysis seems to have been appropriate, and there was adequate presentation and discussion of the findings.

The authors' conclusions seem appropriate in the light of the data they present.

**Implications of the review for practice and research**

Practice: The authors state that the benefits of stretching to reduce muscle soreness are probably too small for most athletes to consider it worthwhile. While muscle stretching protocols do not appreciably reduce the risk of injury in army recruits undergoing military training, it is not possible to rule out with certainty a clinically worthwhile effect of other stretch protocols on the risk of injury in other populations.

Research: The authors state that it would be interesting to determine whether more prolonged stretching carried out by recreational athletes over many months or years can produce meaningful reductions in the risk of injury.

**Bibliographic details**

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http://www.bmj.com/content/325/7362/468

**Other publications of related interest**


This additional published commentary may also be of interest. Arroll B. Review: stretching before or after exercise does not prevent muscle soreness or reduce risk of injury. Evid Based Med 2003;8:54.

**Indexing Status**

Subject indexing assigned by NLM

**MeSH**

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.