TABLE 3. Detailed Summary of Clinical Studies Examining Whether Stretching Immediately Before Exercise Improves Running Performance

Study	Population	Design	Intervention
Stretching beneficial			
Godges et al[32]	7-M*, college recreational athletes with tight hip extensors and/or flexors	Pre-post	(1) Static stretching: 15% body weight ×2 min, gradual increase in load, repeated ×3 with 2-min rest between stretches. Extensors same but only 10% body weight (2) PNF: 1 min PNF for combined extension/abduction/internal rotation pattern. PNF was resisted concentric contraction. Then, 8 min STM: manual pressure of hypomobile myofascia ×8 min for each movement
Little and Williams[29] (also reported in Table 2 for effects on jump)	18 M professional soccer players	Nonrandomized cross-over (stretch, then no stretch, then dynamic), 3 conditions tested within 1 week but at least 1 day between tests	All subjects warmed up, then stretched or no stretch, then higher intensity activity, then 2-min rest before testing session (1) Static stretch: right leg 30 s, left leg 30 s (2) No stretch: rest for 1-min (3) Dynamic stretch: right leg 1 s, left leg 1 s, for a total of 30 stretches (60 s total time) Stretching included gastrocnemius, hamstring, quadriceps, hip flexors, gluteals and hip abductors
Stretching no effect			
Pyke[34] (also reported in Table 2 for effects on jump, ball throw and cycle speed)	45-M 15–17-y, random sample from boys high school	RCT-block design. Blocks based on baseline preintervention scores of outcomes	(1) Strength: 75% effort for pushups, sit-ups, squats (2) Stretch: backward double arm circles, standing trunk turns, standing toe touches
de Vries[33]	4 M, untrained runners, physical education students age 22–26 y	Cross-over repeated measures (10 trials each subject: 1 trial/d for 5 days/wk for 2 wk)	(1) Static stretching: back arch, sitting toe-touch, trunk twist, triceps surae wall stretch, sitting quad stretch, shoulder stretch[57] (2) Control: no stretching

TABLE 3. *(continued)* Detailed Summary of Clinical Studies Examining Whether Stretching Immediately Before Exercise Improves Running Performance

Outcome	Results	Comments
VO_2 at submaximal workloads: 40% (108 m/s), 60% (161 m/s), and 80% (range, 188–228 m/s) VO_{2max}	ROM increased, flexion increased more with static stretching and extension increased more with PNF stretching % VO_2 / Pre / Post Static 40: 20.3 ± 0.7 / 19.0 ± 0.9 60: 35.4 ± 1.2 / 33.9 ± 1.2 80: 43.6 ± 1.1 / 42.0 ± 0.9 PNF/STM 40: 20.1 ± 0.8 / 19.4 ± 0.7 60: 35.7 ± 1.6 / 34.4 ± 1.6 80: 44.0 ± 1.2 / 43.0 ± 1.1	O_2 consumption decrease with PNF stretching only significant at 60% VO_{2max}. Effects with static stretching significant at all levels These results suggest stretching may improve running economy if subject has tight muscles. Note that although running economy improved, competitive times are dependent on muscle endurance and/or contraction velocity in addition to running economy Subjects are likely trained runners as most comfortable speed was at 80% VO_{2max}
10-m sprint standing start Flying 20-m sprint Agility course time	For 10-m sprint, dynamic stretching superior to no stretch ($P = 0.01$) but not different from static stretch ($P = 0.35$). Static and no stretch P value, 0.07 For flying 20-m sprint, dynamic and static produced equivalent results, and both superior to no stretch condition ($P < 0.0005$) For agility time, static and no stretch equivalent, and both inferior to dynamic stretching ($P < 0.0005$) Ten-m sprint(s) Static stretch: 1.85 ± 0.08 No stretch: 1.87 ± 0.09 Dynamic stretch: 1.83 ± 0.08 Flying 20-m (s) Static stretch: 2.37 ± 0.12 No stretch: 2.41 ± 0.13 Dynamic stretch: 2.37 ± 0.13 Agility (s) Static stretch: 5.22 ± 0.18 No stretch: 5.20 ± 0.16 Dynamic stretch: 5.14 ± 0.17	Electronic timing was used for sprints The order of the sessions was not randomized. If there were a learning effect, one would expect the dynamic stretch superior to no stretch superior to static stretch. If there were a fatigue effect, one would expect the opposite Stretches were only 30 s in this study. Other studies use 30 s repeated for a total of 60 s Although running speed was increased, jump height was decreased with static stretching (Table 2)
Standing start, 60-yd dash (6 trials, best of last 3 trials)	Actual results for tests not given; only report F test for overall effect as nonsignificant	ROM not measured Because of multiple outcomes, author accepted only $P < 0.01$ as significant. There were no significant changes, but actual results not given
100-yd dash time on flat asphalt Calculated O_2 consumption	ROM increased for trunk and ankle (only ones measured) Running speed improved with stretching in 2 subjects, and worse with stretching in 2 subjects No difference in calculated O_2 consumption (3.55 vs. 3.53 L/m^2)	No warm-up Wind condition measured and comparable between conditions No food or drink prior to run (done in AM) Subjects hyperventilated before run in order to measure oxygen consumption through expired air

TABLE 3. *(continued)* Detailed Summary of Clinical Studies Examining Whether Stretching Immediately Before Exercise Improves Running Performance

Study	Population	Design	Intervention
Stretching detrimental			
Nelson et al[28]	11 M and 5 F age 21 ± 2 y, university track and field athletes	RCT cross-over with 1 week between sessions	All warmed up and stretched. Then rested for 5–10 min. Groups were: (1) No stretch (2) Both legs stretch (3) Forward leg stretch (4) Rear leg stretch Stretches included passive partner-assisted hamstring and calf and knee-chest, each lasting 30 s, repeated 4× with a 10–20 s rest between stretches

TABLE 3. *(continued)* Detailed Summary of Clinical Studies Examining Whether Stretching Immediately Before Exercise Improves Running Performance

Outcome	Results	Comments
20-m sprint from standard starting blocks. Mean of 3 trials used as outcome	There were no differences between 3 stretch conditions, but the no stretch condition was superior Sprint Time No stretch 3.17 ± 1.90 Both stretch 3.21 ± 0.04 Front stretch 3.21 ± 0.04 Rear stretch 3.22 ± 0.04	ROM not measured The authors used the mean of 3 trials rather than the peak. Some disagreement exists over this choice among experts because the athlete only has to run the fastest once. However, if the athlete cannot do this reproducibly, the athlete is unlikely to get his/her best run at the most important race heat

F indicates females; M indicates males; STM indicates soft tissue mobilization.