Don’t Stretch the Truth: Evidence-Based Stretching Recommendations for Teachers and Coaches

Duane Knudson, Ph.D.
Department of Health & Human Performance

TEXAS STATE UNIVERSITY®

The rising STAR of Texas

Partners

- Dr. Rafael Bahamonde
- Dr. Jeff Bauer
- Dr. John Blackwell
- Dr. Arnold Nelson
- Dr. Peter Magnusson
- Dr. Guillermo Noffal
- Dr. Ian Shrier

Outline

- Why?
- Hypothesis vs. Evidence of Effectiveness
- Flexibility Fitness
- Effects of Stretching
- Applications

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Why?

- Evidence-based practice in kinesiology (Knudson 2005)
- Stretch-induced strength deficits
  - Knudson (1995, 1998, 1999)
  - Highly-cited papers of 'negative' effects (Knudson et al. 2001; 2004)

Stretching During Warm-Up

Do We Have Enough Evidence?

DUANE KNUDSON

In prescribing conditioning, physical educators face many issues that have insufficient or conflicting scientific evidence to inform practice. One example is stretching during warm-up for activity. The traditional measurements of the limits of joint(s) motion, while dynamic flexibility is usually examined by biomechanical measures of muscle stiffness (Gleim & McHugh, 1997). In essence, static flexibility refers to the actual limits of the decreased joint stability (Liebesman & Cafarelli, 1994; Surburg, 1983), so improper or excessive stretching may create unwanted joint instability (Beaulieu, 1981; Kulund & Tottossy, 1983; Safran, Seaber, & Garrett, 1989).

The New York Times

Search All NYTimes.com

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION | ARTS | STYLE | TRAVEL | JOBS

BASEBALL | PRO FOOTBALL | COLLEGE FOOTBALL | PRO BASKETBALL | OLYMPICS 2008 | HOCKEY | SOCCER | GOLF | TENNIS | MORE SP

PHYS ED

Stretching: The Truth

By GRETCHEN REYNOLDS
Published: October 31, 2008

TWITTER
LINKEDIN
SIGN IN TO E-MAIL OR SAVE THIS
PRINT
REPRINTS
SHARE

WHEN DUANE KNUDSON, a professor of kinesiology at California State University, Chico, looks around campus at athletes warming up before practice, he sees one dangerous mistake after another. "They're stretching, touching their toes. . . ." He sighs. "It's discouraging."

Enlarge This Image

If you're like most of us, you were taught the importance of warm-up exercises back in grade school, and you've likely continued with pretty much the same routine ever since.

More Articles in Sports »

MOST POPULAR

Why?

- Evidence-Based practice in kinesiology
  - Effectiveness
  - Efficient use of time
- Surprising flexibility & stretching effects
  - Desirable flexibility
  - Different acute and chronic effects
  - Stretch-induced strength deficits
  - Affecting energy-return but not stiffness

Hypothesis vs Evidence

- Old: Ekstrand et al. (1983)
  - Interpreted as support of
    - Ho of stretching is important to reduce risk of injuries
    - Ho that more ROM must be better
  - Expert opinion and “best practice”

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Evidence

- Acute effects of stretching
  - Basic and clinical science research provides little evidence of a protective effect of stretching (Knudson 1999; Shirer 1999; Weldon & Hill, 2003)
  - The best and largest prospective studies show no differences in musculoskeletal injuries in warm-ups with and without stretching (Amako et al. 2003; Pope et al. 1998; 2000; Small et al. 2008)

Hypothesis vs Evidence

- Prospective studies showed these hypotheses to be incorrect
  - More flexibility ≠ lower injury rate
  - Pre-activity stretching ≠ lower injury rate or enhanced performance
- New: Teachers and coaches should
  - Utilize warm-ups without stretching
  - Strive to use evidence to define best practice

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Flexibility Fitness

- Old: ROM
- New: "The intrinsic property of body tissues which determines the range of motion achievable without injury at a joint or group of joints." (Holt et al. 1996)
- Test for desirable flexibility
- Train to maintain

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Test

- Test
  - SRT valid field test of hamstring static flexibility (SF) for healthy populations (Martin et al. 1998)
  - Subjective, based primarily on stretch-tolerance (Magnusson et al. 1996, 1997), and is less than passive (tester assisted) flexibility

TEXAS STATE UNIVERSITY
The rising STAR of Texas

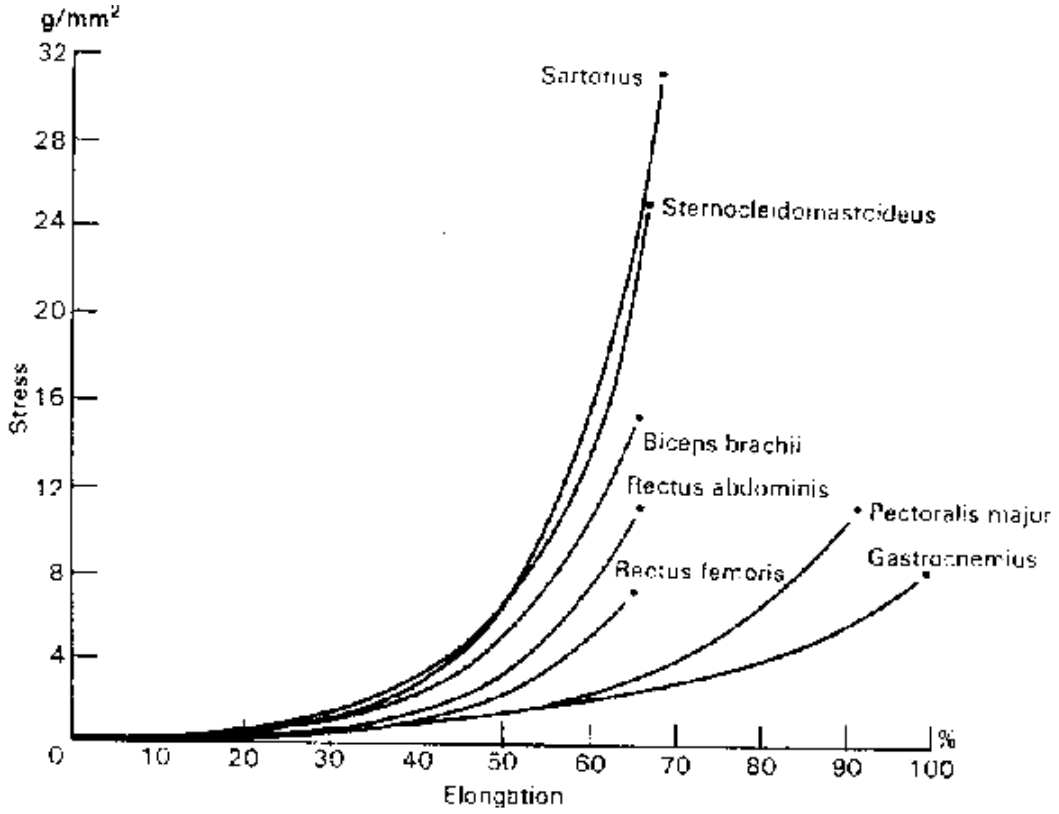
Evidence

- SF is a function of many variables
  - Bony architecture
  - Ligaments
  - MTU stiffness/compliance
  - Neuromuscular factors (stretch tolerance)

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Evidence

- Elongation of muscle resisted by the passive tension created by straightening (collagen) and tensile resistance of connective tissue within muscle tendon unit (MTU)

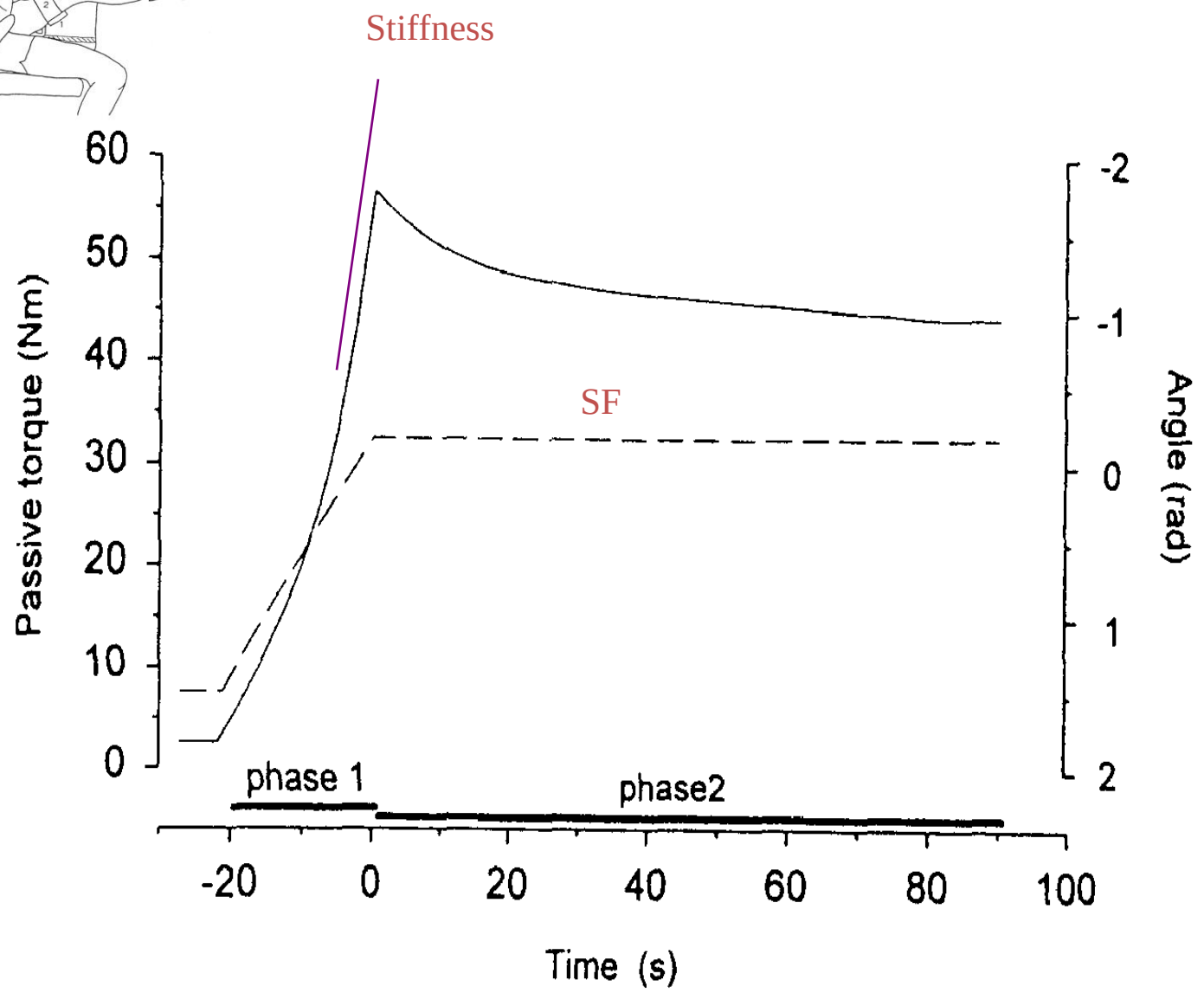


TEXAS STATE UNIVERSITY
The rising STAR of Texas

Evidence

- Passive tension ≠ stiffness ≠ SF
  - Stiffness—slope of the linear (elastic) region of the load/deformation curve (N/m)
  - Compliance—opposite of stiffness (m/N)
  - Has been colloquially called dynamic flexibility (DF) for healthy populations (Martin et al. 1998)
  - Can be approximated *in vivo* as the rate of increase in passive torque versus angle
  - SF and stiffness moderately (r^2 = 44 to 66%) related (Magnusson et al. 1997; McHugh et al. 1998)

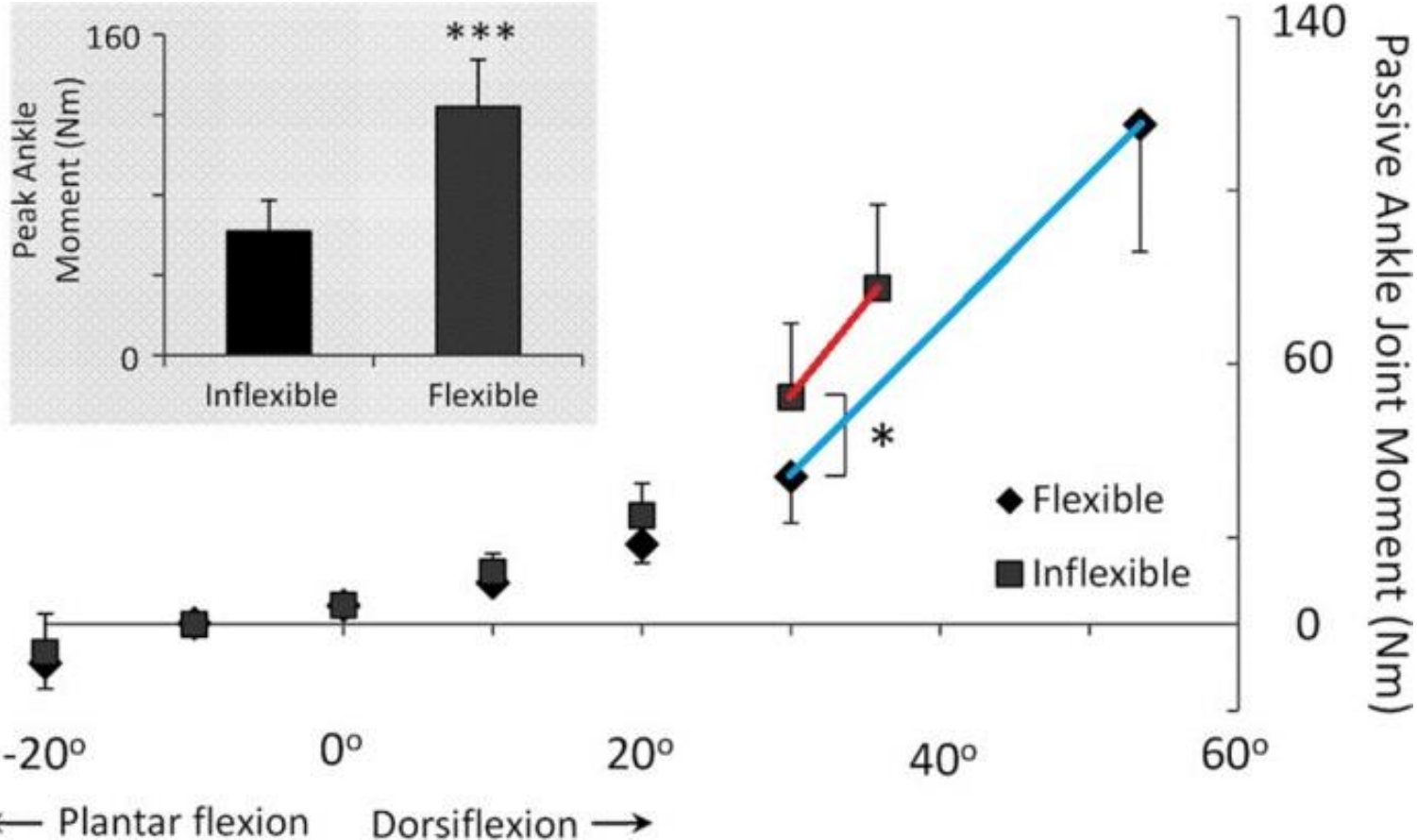
Magnusson et al. (1996)



TEXAS STATE UNIVERSITY
The rising STAR of Texas

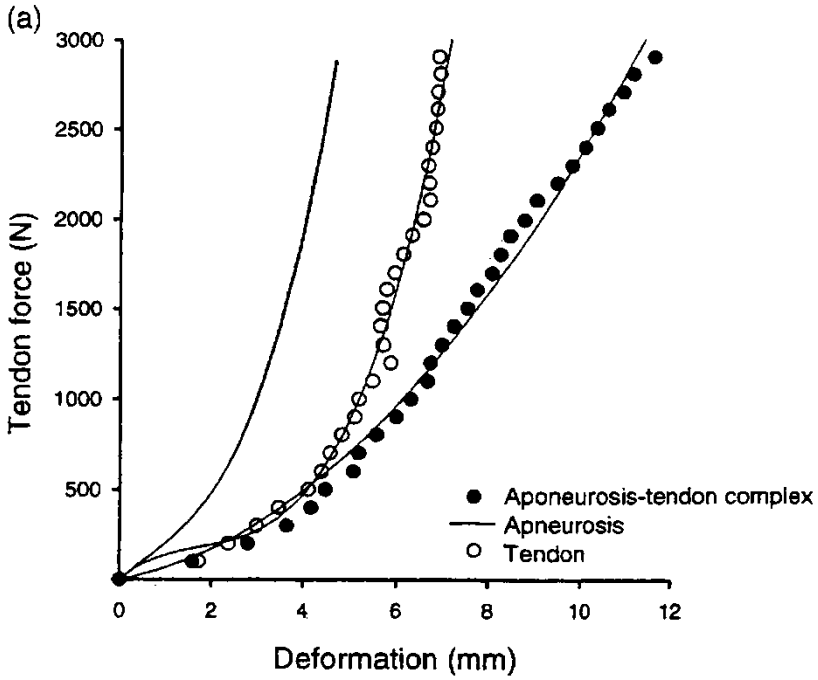
Stretch

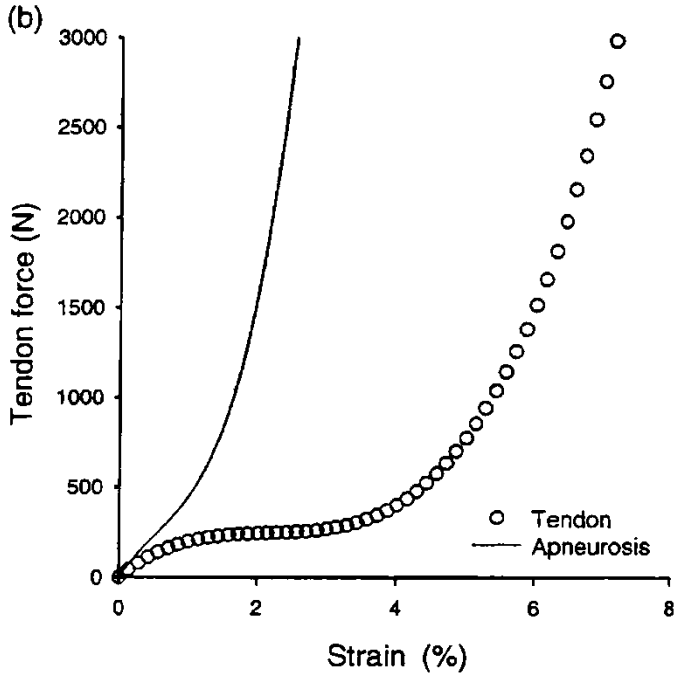
- Maximal stretch of plantar flexors creates 15% elongation of muscle fibers and 8% tendon
- Greater SF is neuromuscular—less resistance to stretch and later onset of EMG (Blazevich et al. 2012)

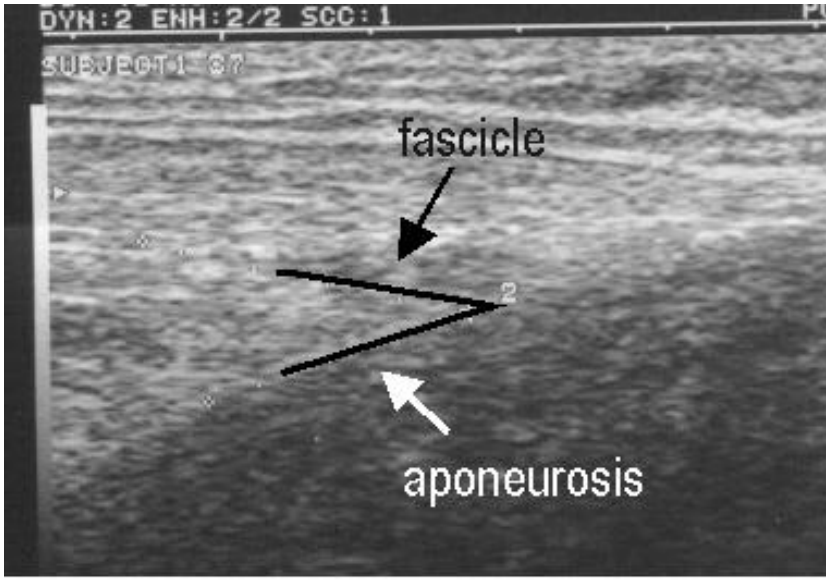


TEXAS STATE UNIVERSITY
The rising STAR of Texas

Magnusson et al. (2003)







TEXAS STATE UNIVERSITY
The rising STAR of Texas

Test

- Regularly test static flexibility
- Major muscle groups
- Sport and individual problem areas

Test

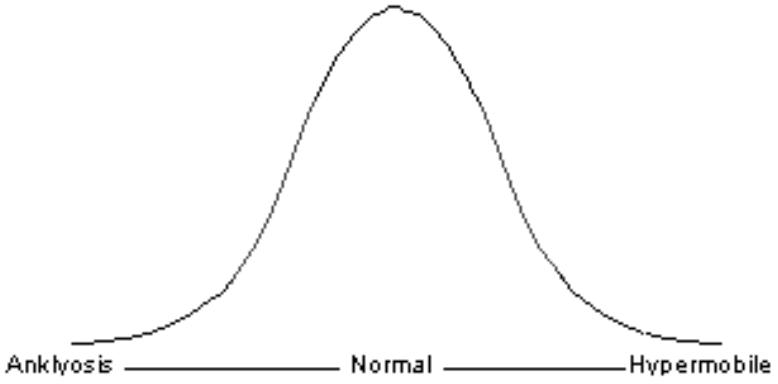
- Desirable SF?
  - Old: More flexibility is always better
  - New: Target should be normal/moderate SF

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Apply

Desirable Flexibility?

- Performance
  - Negative correlation between SF and running economy (Craib et al. 1996; Gleim et al. 1990; Jones 2002)
  - Stretch training that increases SF does not effect running economy (Nelson et al. 2001)
- Muscular Injury
  - Stability—mobility paradox
  - Highest injury rates are people in top and bottom 20% of SF distribution (Knapik et al. 1992; Jones & Knapik, 1999)



TEXAS STATE UNIVERSITY
The rising STAR of Texas

Train to Maintain

- Old: Stretch Warm-up & Cool-Down
- New: Targeted stretch late in conditioning
  - Warm-up
  - Stretching (acute and chronic effects)
  - Full, safe ROM in exercises and skills
  - Manual Therapy: Massage & Foam Rolling

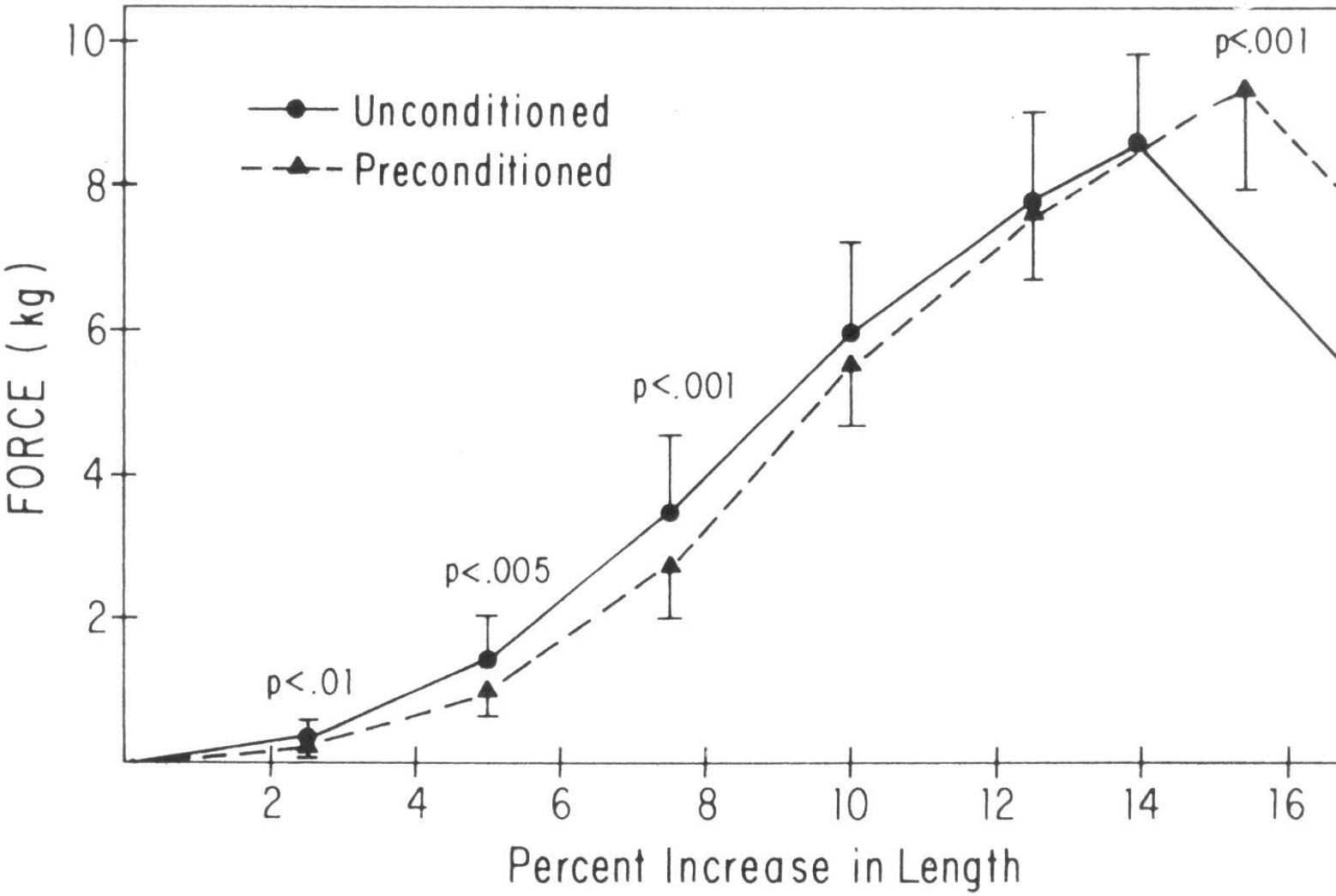
TEXAS STATE UNIVERSITY
The rising STAR of Texas

Warm-up

- Performance Benefits (3-10%) primarily in large muscle group movements (Bishop, 2003)
- Injury Risk Benefits
  - MTU ROM, strength, and compliance ↑
  - Abnormal cardiac response to sudden exertion ↓
  - Passive motion stretch ↓ stiffness when holds do not (McNair et al. 2000)
- Mechanisms
  - Thermal
  - Neuromuscular
  - Psychological

Warm-up increases mechanical strength—max force or energy absorbed before failure

Safran et al. (1988)



TEXAS STATE UNIVERSITY
The rising STAR of Texas

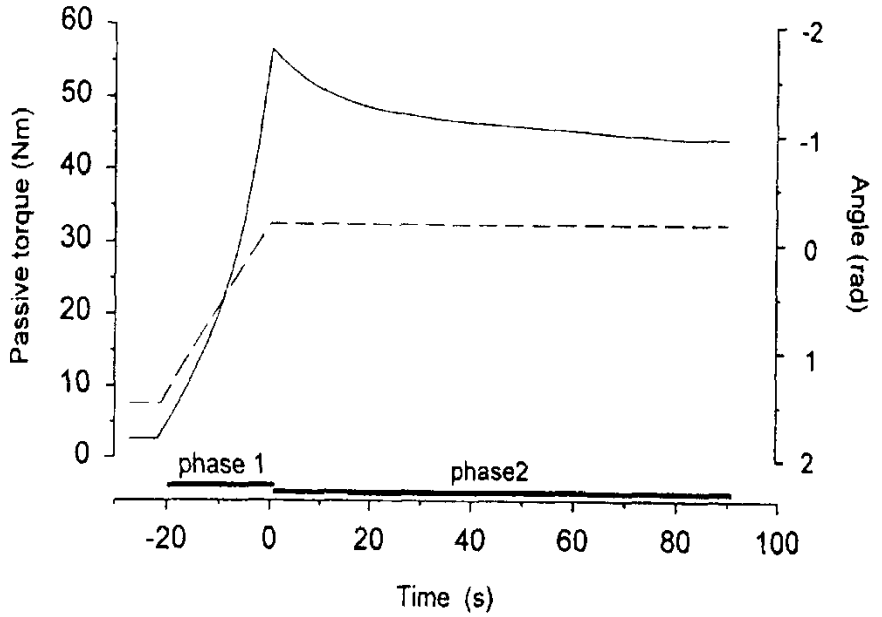
Mechanics of Materials

- Viscoelasticity—material response that is both rate and elongation dependent
  - SR—↓ in load with constant elongation
  - Creep—↑ in length constant tensile stretch
  - Hysteresis — energy loss in restitution

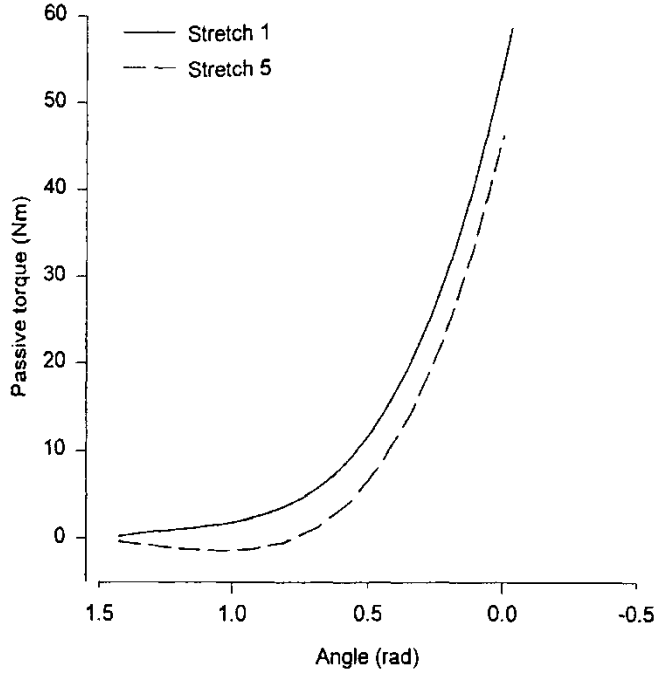
Stretching

- Acute Effects (Knudson 1999, 2006; Shrier, 2007)
  - 4-20% ↑in SF (tolerance & residual strain)
  - 10-30% ↓ passive tension
  - Little effect on stiffness
  - Larger improvement in hysteresis
  - Neuromuscular inhibition—Large reductions (40-80%) in reflex sensitivity (Avela et al. 1999)

TEXAS STATE UNIVERSITY
The rising STAR of Texas

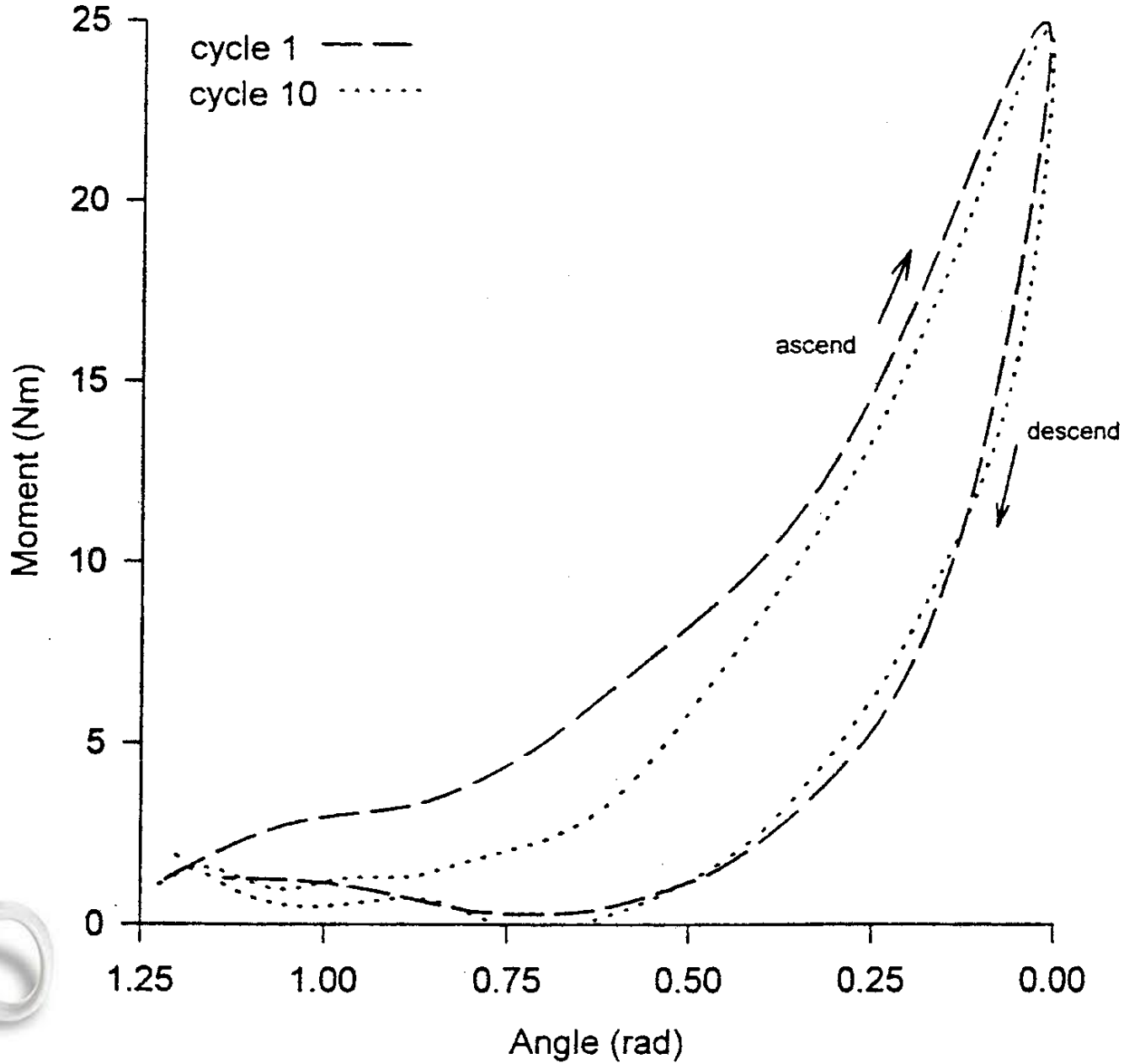


Magnusson et al. (1996)



TEXAS STATE UNIVERSITY
The rising STAR of Texas

Magnusson et al. (1998)



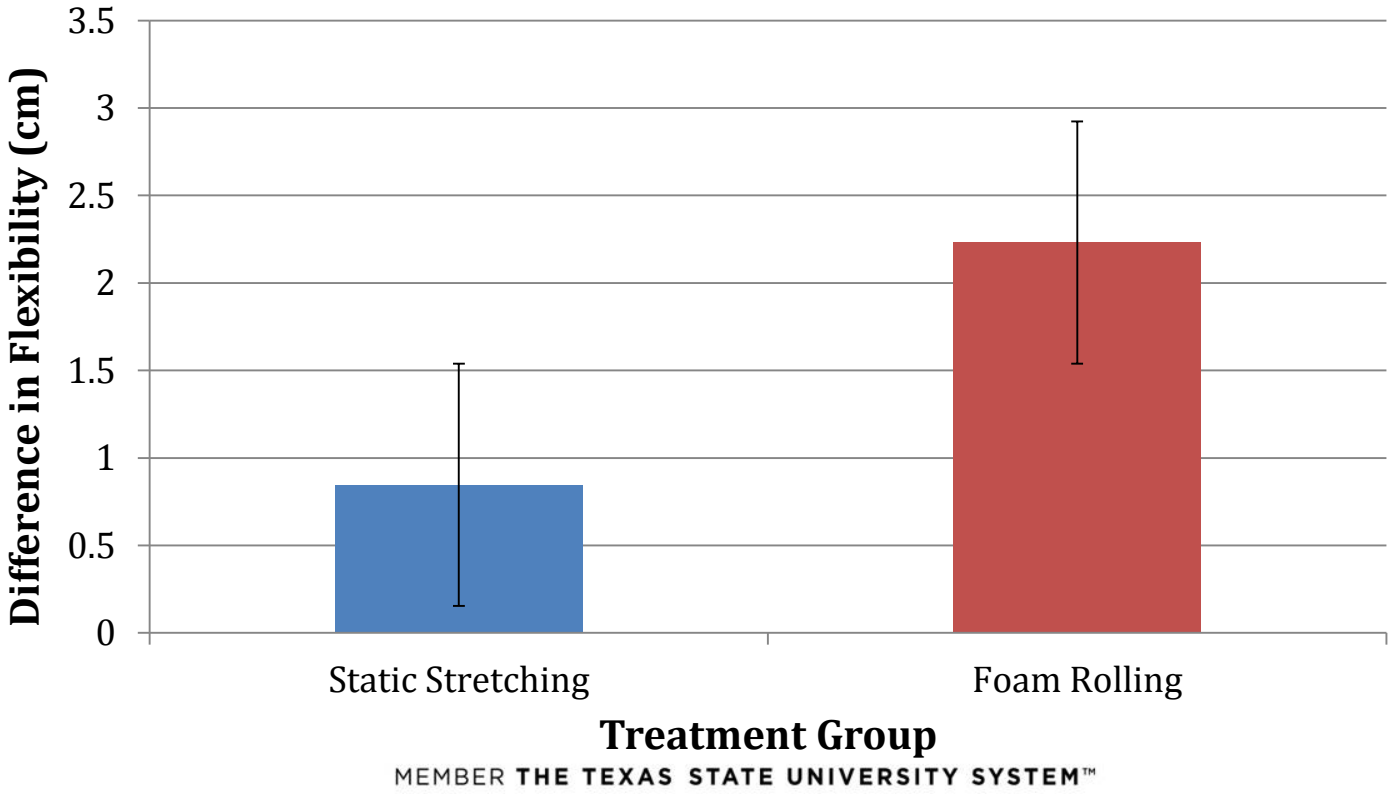
TEXAS STATE UNIVERSITY
The rising STAR of Texas

Tendon

- Disuse ↓ stiffness (Kubo et al. 2000)
- Kubo et al. (2002a) compared 5 min stretching and 50 MVC on Achilles tendon
  - SS ↓ stiffness 8% ↓ hysteresis 30%
  - MVC ↓ stiffness 27%

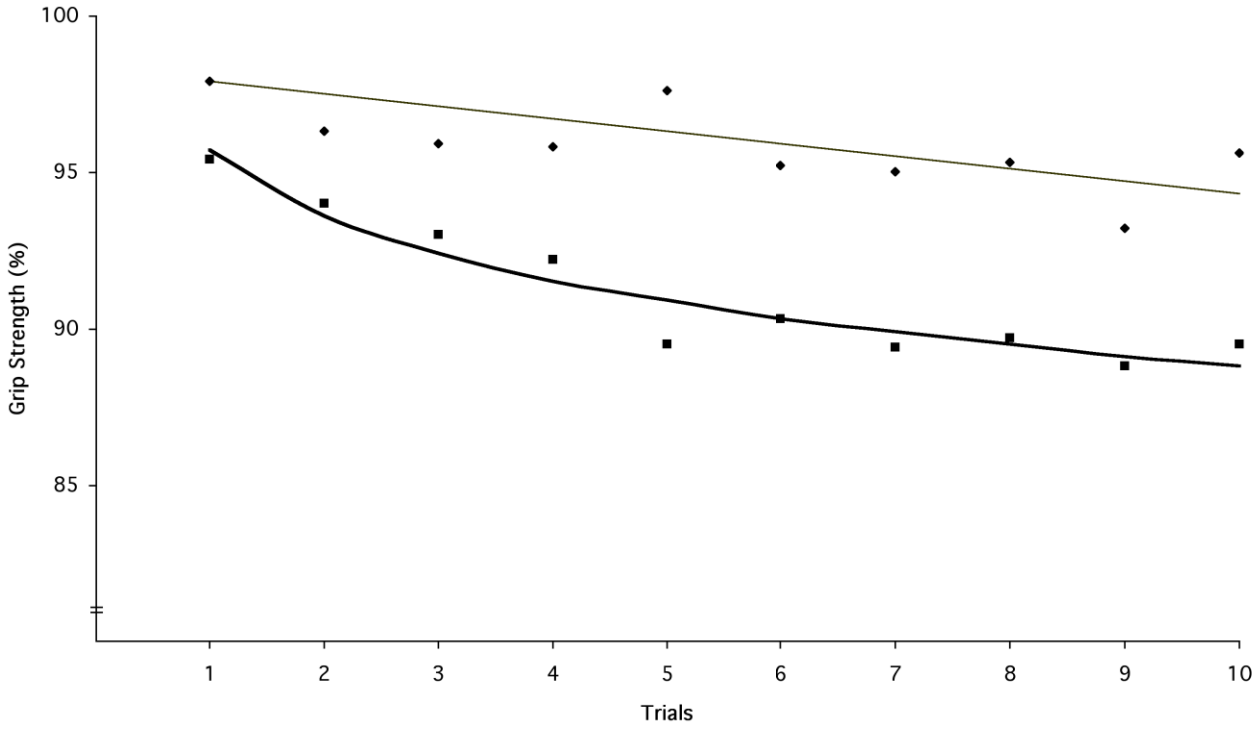
Foam Rolling

Gerken et al. (2013)



Stretching & Performance

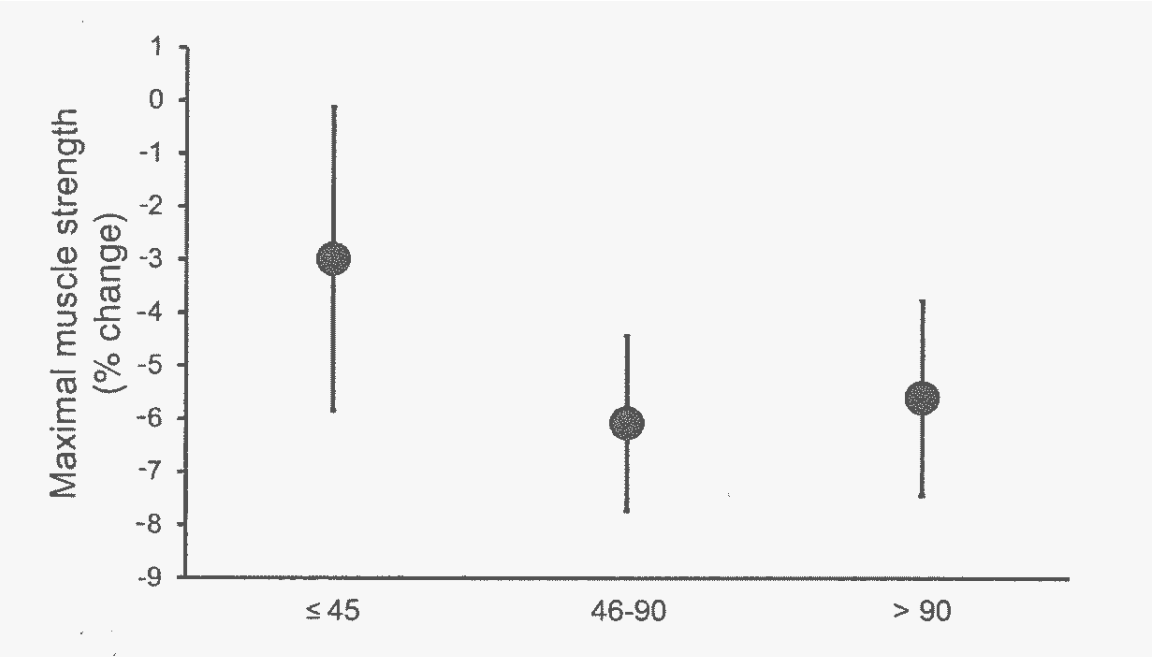
- Muscular strength decreases after stretching follow logarithmic dose-response (Knudson & Noffal, 2005)
  - 10 s -4.6%
  - 40 s -7.8%



TEXAS STATE UNIVERSITY
The rising STAR of Texas

Stretching & Performance

- Since 1997 there have been over 100 studies published on the acute effect of stretching on muscular performance
- Recent meta-analysis by Simic et al. (2013)



TEXAS STATE UNIVERSITY
The rising STAR of Texas

Stretching: Acute Effects

- New: Application Summary
  - Stretch train to individual needs
  - F: 3 times per week, daily or after physical activity
  - I: slowly elongate and hold at low force levels
  - T: 4 - 5 stretches held 15 - 30 sec for each muscle group during the cool-down
  - T: Static or PNF stretches

Knudson et al. (2000)

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Stretching

- Chronic Effects
  - 15 to 33% ↑ in SF over 4-6 weeks (Gajdosik et al. 2007; Marshall et al. 2011; Weppler & Magnusson, 2010)
  - Three weeks of stretch training NS effect on stiffness, but 37% ↓ hysteresis (Kubo et al. 2002b), and cannot counteract ↑ MTU stiffness with strength training (Klinge et al. 1997)
  - Decreases sensitivity to passive tension in stretch (Ben & Harvey, 2010)

Stretching and Performance

- The activities were a stiff or compliant MTU would be an advantage is unclear
  - Compliant MTU: advantage in SSC (Kubo et al. 1999,2000; Wilson et al. 1991, 1992)
  - Stiff MTU: advantage in isometric and concentric actions (Wilson et al. 1994)

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Stretching: Chronic Effects

- New: Application Summary
  - Stretch maintain normal SF or needs of sport
  - Use cool-down for safety and recovery
  - Greater stretch training emphasis for:
    - High SF demand sports
    - SSC movements through decrease in hysteresis
  - Maintenance stretch training for:
    - Strength sports
    - General fitness

Application Examples

- Physical Education
  - Teach/Review Time: Transitions and Cool-Down
  - Target: Health-related areas (hamstring, low-back, ant. chest/shoulder), key muscle groups related to activity, and individual needs
  - Efficiency: Two 20-second stretches per muscle group
  - Stretching in PE twice a week ↑ SLR 9 degrees while 4 times a week ↑ SLR 17 degrees (Medina et al. 2007)

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Application Examples

- Athletics
  - Teach/Train Time: Transitions and Cool-Down
  - Target: Key muscle groups related to sport and individual needs
  - Train: Three or four stretches, 20 to 30 seconds per muscle group and more for flexibility-intense sports

TEXAS STATE UNIVERSITY
The rising STAR of Texas

Application Examples

- Intramurals and Community Recreation
  - Time: Cool-Down
  - Target: Health-related areas (hamstring, low-back), key muscle groups related to activity, and individual needs
  - Efficiency: Two 20-second stretches per muscle group

Apply

TEXAS STATE UNIVERSITY
The rising STAR of Texas

References

Amako et al 2003 *Mil Med* 168:442

Avela et al 1999 *J App Physiol* 86:1283

Blazevich et al 2012 *J App Physiol* 113:1446

Fowles et al 2000 *J App Physiol* 89:1179

Hasselman et al 1995 *Am J Sport Med* 23:65

Holt et al 1996 *Biom in Sprts XIII* 13:170

Klinge et al 1997 *Am J Sports Med* 25:710

Knudson 1999 *JOPERD* 70(7):24

Knudson et al 2000 *PCPFS Res Digest* 3(10)

Knudson et al 2001 *J Str Cond Res* 15:98

Knudson et al 2004 *J Str Cond Res* 18:654

Knudson & Noffal 2005 *Eur J Appl Physiol* 94: 348

Kokkonen et al 1998 *Res Quart Ex Sport* 69:411

Kubo et al 1999 *J App Physiol* 87: 2090

Kubo et al 2000 *Acta Physiol Scand* 168:327

References

Kubo et al 2002a *Acta Physiol Scand* 175:157

Kubo et al 2002b *J App Physiol* 92: 595

Lieber et al 1991 *J App Physiol* 70: 2498

Lieber & Friden 1993 *J App Phyiol* 74:520

Magnusson 1998 *Scand J Med Sci Sports* 8: 65

Magnusson et al 1996 *Am J Sports Med* 24: 622

Magnusson et al 1997 *Sand J Med Sci Sports* 7:195

Magnusson et al. 1998 *Int J Sports Med* 19:310

Magnusson et al 2000 *Med Sci Sports Ex* 32:1160

Magnusson et al 2003 *Act Physiol Scand* 177:185

Marshall et al. 2011 *J Sci Med Sport* 14:535

McHugh et al 1998 *Med Sci Sport Ex* 30: 928

McHugh et al 1999 *Am J Sports Med* 27: 594

Nelson et al 2001a *Res Quart Ex Sport* 72: 415

References

Nelson et al 2001b *J St Cond Res* 15: 241

Nelson et al 2001c *Scand J Med Sci Sports* 11: 260

Pope et al 1998 *Aust J Physio* 44:165

Pope et al 2000 *Med Sci Sports Ex* 32: 271

Safran et al 1988 *Am J Sports Med* 16: 123

Shrier 1999 *Can J Sport Med* 9: 221

Simic et al 2013 *Scan J Med Sci Sports* 23:131

Small et al 2008 *Res Sports Med* 16:213

Weppler et al. 2010 *Phys Ther* 90:438

Wilson et al 1991 *J App Physiol* 70: 825

Wilson et al 1992 *Med Sci Sports Ex* 24:116

Wilson et al 1994 *J App Physiol* 76: 2714