PERFORMING ARTS
SPECIAL INTEREST GROUP

ORTHOPAEDIC SECTION
AMERICAN PHYSICAL THERAPY ASSOCIATION

APTA
American Physical Therapy Association
The Science of Healing. The Art of Caring.

PASIG MONTHLY CITATION BLAST: No.76 October 2012

Dear Performing Arts SIG members:

I would like to draw your attention to the change in venue and date for this year's APTA Combined Sections Meeting.
The 2013 APTA Combined Sections Meeting will be held January 21-24 in San Diego, CA.
http://www.apta.org/csm/

Please consider compiling and contributing a brief summary of Performing Arts-related abstracts for citation blast this year. It's easy to do, and a great way to become involved with PASIG! Just take a look at our Performing Arts Citations and Endnotes, look for what's missing, and email me your contribution!
http://www.orthopt.org/content/special_interest_groups/performing_arts/citations_endnotes

This month's abstract citation and topic summary on the Effects of Stretching is given by one of our PASIG research committee members, Sheyi Ojofeitimi, PT, DPT, OCS. Thank you, Sheyi!!

Best regards,

Annette

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PERFORMING ARTS CONTINUING EDUCATION, CONFERENCES, AND RESOURCES

Orthopaedic Section Independent Study Course. *20.3 Physical Therapy for the Performing Artist*.
Monographs are available for:
- Figure Skating (J. Flug, J. Schneider, E. Greenberg),
- Artistic Gymnastics (A. Hunter-Giordano, Pongetti-Angeletti, S. Voelker, TJ Manal), and
- Instrumentalist Musicians (J. Dommerholt, B. Collier).

Contact: Orthopaedic Section at: www.orthopt.org

Orthopaedic Section Independent Study Course. *Dance Medicine: Strategies for the Prevention and Care of Injuries to Dancers*.
This is a 6-monograph course and includes many PASIG members as authors.
- Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health (MJ Liederbach),
- Nutrition, Hydration, Metabolism, and Thinness (B Glace),
- The Dancer's Hip: Anatomic, Biomechanical, and Rehabilitation Considerations (G. Grossman),
- Common Knee Injuries in Dance (MJ Liederbach),
- Foot and Ankle Injuries in the Dancer: Examination and Treatment Strategies (M. Molnar, R. Bernstein, M. Hartog, L. Henry, M. Rodriguez, J. Smith, A. Zujko),
- Developing Expert Physical Therapy Practice in Dance Medicine (J. Gamboa, S. Bronner, TJ Manal).

Contact: Orthopaedic Section at: www.orthopt.org

Orthopaedic Section-American Physical Therapy Association,
Performing Arts SIG
http://www.orthopt.org/content/special_interest_groups/performing_arts
Performing Arts Citations and Endnotes
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ADAM Center
http://www.adamcenter.net/
Publications:
http://www.adamcenter.net/#!vstc0=publications
Conference abstracts:
http://www.adamcenter.net/#!vstc0=conferences

Dance USA
Annual conference: Philadelphia, PA, June 12-15, 2013
http://www.danceusa.org/
Research resources:
http://www.danceusa.org/researchresources
Professional Dancer Annual Post-Hire Health Screen:
http://www.danceusa.org/dancerhealth

Dancer Wellness Project
http://www.dancerwellnessproject.com/
Becoming an affiliate:
http://www.dancerwellnessproject.com/Information/BecomeAffiliate.aspx

Harkness Center for Dance Injuries, Hospital for Joint Diseases
http://hjd.med.nyu.edu/harkness/
Continuing education:
http://hjd.med.nyu.edu/harkness/education/healthcare-professionals/continuing-education-courses-cme-and-ceu
Resource papers:
http://hjd.med.nyu.edu/harkness/dance-medicine-resources/resource-papers-and-forms
Links:
http://hjd.med.nyu.edu/harkness/dance-medicine-resources/links
Informative list of common dance injuries:
http://hjd.med.nyu.edu/harkness/patients/common-dance-injuries
Research publications:
http://hjd.med.nyu.edu/harkness/research/research-publications

International Association for Dance Medicine and Science (IADMS)
22nd Annual Meeting, Singapore. October 25 – 28, 2012
http://www.iadms.org/
Resource papers:
http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=186
Links:
http://www.iadms.org/displaycommon.cfm?an=5
Medicine, arts medicine, and arts education organization links:
http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=5
Publications:
http://www.iadms.org/displaycommon.cfm?an=3

Performing Arts Medicine Association (PAMA)
http://www.artsmed.org/
Annual symposium:
http://www.artsmed.org/symposium.html
Interactive bibliography site:
http://www.artsmed.org/bibliography.html
Related links:
http://www.artsmed.org/relatedlinks.html
Member publications:
http://artsmed.org/publications.html

(Educators, researchers, and clinicians, please continue to email me your conference and continuing education information and I will include it in the upcoming blasts.)

The effects of stretching

Stretching is a necessity for all athletes (dancers included). However, therapists and dancer alike should be aware of the advantages and limitations of stretching. For example, studies show that stretching:

1. improves flexibility
2. helps with sports that require above normal flexibility
3. can slightly decrease your risk of muscle strain
4. does *not* decrease your risk of overall injuries
5. does not decrease muscle soreness
6. greater than 45 seconds (static stretch) has been shown to decrease muscular strength, power, and explosive performance for up to an hour.

This citation blast consists of recent articles on this topic on varying populations.

Sheyi Ojofeitimi PT, DPT, OCS,sojofeit@gmail.com

Amiri-Khorasani, M., M. Sahebozamani, et al. (2010). "Acute effect of different stretching methods on Illinois agility test in soccer players." J Strength Cond Res **24**(10): 2698-2704.

The purpose of this study was to examine the effects of static, dynamic, and the combination of static and dynamic stretching within a pre-exercise warm-up on the Illinois agility test (IAT) in soccer players. Nineteen professional soccer players (age = 22.5 +/- 2.5 years, height = 1.79 +/-

0.003 m, body mass = 74.8 +/- 10.9 kg) were tested for agility performance using the IAT after different warm-up protocols consisting of static, dynamic, combined stretching, and no stretching. The players were subgrouped into less and more experienced players (5.12 +/- 0.83 and 8.18 +/- 1.16 years, respectively). There were significant decreases in agility time after no stretching, among no stretching vs. static stretching; after dynamic stretching, among static vs. dynamic stretching; and after dynamic stretching, among dynamic vs. combined stretching during warm-ups for the agility: mean +/- SD data were 14.18 +/- 0.66 seconds (no stretch), 14.90 +/- 0.38 seconds (static), 13.95 +/- 0.32 seconds (dynamic), and 14.50 +/- 0.35 seconds (combined). There was significant difference between less and more experienced players after no stretching and dynamic stretching. There was significant decrease in agility time following dynamic stretching vs. static stretching in both less and more experienced players. Static stretching does not appear to be detrimental to agility performance when combined with dynamic warm-up for professional soccer players. However, dynamic stretching during the warm-up was most effective as preparation for agility performance. The data from this study suggest that more experienced players demonstrate better agility skills due to years of training and playing soccer.

Barroso, R., V. Tricoli, et al. (2012). "Maximal strength, number of repetitions, and total volume are differently affected by static-, ballistic-, and proprioceptive neuromuscular facilitation stretching." J Strength Cond Res **26**(9): 2432-2437.

ABSTRACT: Barroso, R, Tricoli, V, dos Santos Gil, S, Ugrinowitsch, C, and Roschel, H. Maximal strength, number of repetitions, and total volume are differently affected by static-, ballistic-, and proprioceptive neuromuscular facilitation stretching. J Strength Cond Res 26(9): 2432-2437, 2012-Stretching exercises have been traditionally incorporated into warm-up routines before training sessions and sport events. However, the effects of stretching on maximal strength and strength endurance performance seem to depend on the type of stretching employed. The objective of this study was to compare the effects of static stretching (SS), ballistic stretching (BS), and proprioceptive neuromuscular facilitation (PNF) stretching on maximal strength, number of repetitions at a submaximal load, and total volume (i.e., number of repetitions x external load) in a multiple-set resistance training bout. Twelve strength-trained men (20.4 +/- 4.5 years, 67.9 +/- 6.3 kg, 173.3 +/- 8.5 cm) volunteered to participate in this study. All of the subjects completed 8 experimental sessions. Four experimental sessions were designed to test maximal strength in the leg press (i.e., 1 repetition maximum [1RM]) after each stretching condition (SS, BS, PNF, or no-stretching [NS]). During the other 4 sessions, the number of repetitions performed at 80% 1RM was assessed after each stretching condition. All of the stretching protocols

significantly improved the range of motion in the sit-and-reach test when compared with NS. Further, PNF induced greater changes in the sit-and-reach test than BS did (4.7 +/- 1.6, 2.9 +/- 1.5, and 1.9 +/- 1.4 cm for PNF, SS, and BS, respectively). Leg press 1RM values were decreased only after the PNF condition (5.5%, $p < 0.001$). All the stretching protocols significantly reduced the number of repetitions (SS: 20.8%, $p < 0.001$; BS: 17.8%, $p = 0.01$; PNF: 22.7%, $p < 0.001$) and total volume (SS: 20.4%, $p < 0.001$; BS: 17.9%, $p = 0.01$; PNF: 22.4%, $p < 0.001$) when compared with NS. The results from this study suggest that, to avoid a decrease in both the number of repetitions and total volume, stretching exercises should not be performed before a resistance training session. Additionally, strength-trained individuals may experience reduced maximal dynamic strength after PNF stretching.

Handrakis, J. P., V. N. Southard, et al. (2010). "Static stretching does not impair performance in active middle-aged adults." J Strength Cond Res **24**(3): 825-830.

Recent investigations with young, healthy adult subjects suggest that static stretching before activity decreases performance and should, therefore, be avoided. The purpose of this study was to assess the effects of an acute static stretching protocol on balance and jump/hop performance in active middle-aged adults. Ten subjects (6 men and 4 women aged 40-60 yr) from a martial arts school volunteered to take part in this research study. This was a repeated measures design. Subjects who stretched for 10 minutes using a 30-second hold during 1 session sat quietly for 10 minutes during the alternate session. Sessions were randomly assigned. The following dependent variables were compared: Dynamic Stability Index (DSI) for single-leg dynamic balance (smaller DSI = improved balance); distances for broad jump, single hop, triple hop, and crossover hop; elapsed time for a 6-m timed hop. Group means for balance were significantly different between the stretch and no-stretch conditions (3.5 +/- 0.7 vs. 4.3 +/- 1.4 DSI, respectively; $p < 0.05$). No significant differences were found between the group means of the stretch and no-stretch conditions for the dependent measures of broad jump, single hop, triple hop, crossover hop, and 6-m timed hop performance. Ten minutes of acute static stretching enhances dynamic balance and does not affect jump/hop performance in active middle-aged adults. Static stretching should be included before competition and before exercise in fitness programs of active middle-aged adults.

Herbert, R. D. and M. de Noronha (2007). "Stretching to prevent or reduce muscle soreness after exercise." Cochrane Database Syst Rev(4): CD004577.

BACKGROUND: Many people stretch before or after (or both) engaging in athletic activity. Usually the purpose is to reduce risk of injury, reduce soreness after exercise, or enhance athletic performance. OBJECTIVES:

The aim of this review was to determine effects of stretching before or after exercise on the development of post-exercise muscle soreness. SEARCH STRATEGY: We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (to April 2006), the Cochrane Central Register of Controlled Trials (The Cochrane Library 2006, Issue 2), MEDLINE (1966 to May 2006), EMBASE (1988 to May 2006), CINAHL (1982 to May 2006), SPORTDiscus (1949 to May 2006), PEDro (to May 2006) and reference lists of articles. SELECTION CRITERIA: Eligible studies were randomised or quasi-randomised studies of any pre-or post-exercise stretching technique designed to prevent or treat delayed-onset muscle soreness (DOMS), provided the stretching was conducted soon before or soon after exercise. To be eligible studies must have assessed muscle soreness or tenderness. DATA COLLECTION AND ANALYSIS: Methodological quality of the studies was assessed using the Cochrane Bone, Joint and Muscle Trauma Group's methodological quality assessment tool. Estimates of effects of stretching were converted to a common 100-point scale. Outcomes were pooled in a fixed-effect meta-analysis. MAIN RESULTS: Of the 10 included studies, nine were carried out in laboratory settings using standardised exercise protocols and one involved post-exercise stretching in footballers. All participants were young healthy adults. Three studies examined the effects of stretching before exercise and seven studies investigated the effects of stretching after exercise. Two studies, 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. All studies were small (between 10 and 30 participants received the stretch condition) and of questionable quality. The effects of stretching reported in individual studies were very small and there was a high degree of consistency of results across studies. 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 studies). Post-exercise stretching reduced soreness one day after exercise by, on average, 1.0 points on a 100-point scale (95% CI -6.9 to 4.8; 4 studies). Similar effects were evident between half a day and three days after exercise. AUTHORS' CONCLUSIONS: The evidence derived from mainly laboratory-based studies of stretching indicate that muscle stretching does not reduce delayed-onset muscle soreness in young healthy adults.

Herbert, R. D. and M. Gabriel (2002). "Effects of stretching before and after exercising on muscle soreness and risk of injury: systematic review." BMJ **325**(7362): 468.

OBJECTIVE: To determine the effects of stretching before and after exercising on muscle soreness after exercise, risk of injury, and athletic performance. METHOD: Systematic review. DATA SOURCES:

Randomised or quasi-randomised studies identified by searching Medline, Embase, CINAHL, SPORTDiscus, and PEDro, and by recursive checking of bibliographies. MAIN OUTCOME MEASURES: Muscle soreness, incidence of injury, athletic performance. RESULTS: Five studies, all of moderate quality, reported sufficient data on the effects of stretching on muscle soreness to be included in the analysis. Outcomes seemed homogeneous. Stretching produced small and statistically non-significant reductions in muscle soreness. The pooled estimate of reduction in muscle soreness 24 hours after exercising was only 0.9 mm on a 100 mm scale (95% confidence interval -2.6 mm to 4.4 mm). Data from two studies on army recruits in military training show that muscle stretching before exercising does not produce useful reductions in injury risk (pooled hazard ratio 0.95, 0.78 to 1.16). CONCLUSIONS: Stretching before or after exercising does not confer protection from muscle soreness. Stretching before exercising does not seem to confer a practically useful reduction in the risk of injury, but the generality of this finding needs testing. Insufficient research has been done with which to determine the effects of stretching on sporting performance.

Kinser, A. M., M. W. Ramsey, et al. (2008). "Vibration and stretching effects on flexibility and explosive strength in young gymnasts." Med Sci Sports Exerc **40**(1): 133-140.

PURPOSE: Effects of simultaneous vibration-stretching on flexibility and explosive strength in competitive female gymnasts were examined. METHODS: Twenty-two female athletes (age = 11.3 +/- 2.6 yr; body mass = 35.3 +/- 11.6 kg; competitive levels = 3-9) composed the simultaneous vibration-stretching (VS) group, which performed both tests. Flexibility testing control groups were stretching-only (SF) (N = 7) and vibration-only (VF) (N = 8). Explosive strength-control groups were stretching-only (SES) (N = 8) and vibration-only (VES) (N = 7). Vibration (30 Hz, 2-mm displacement) was applied to four sites, four times for 10 s, with 5 s of rest in between. Right and left forward-split (RFS and LFS) flexibility was measured by the distance between the ground and the anterior suprailiac spine. A force plate (sampling rate, 1000 Hz) recorded countermovement and static jump characteristics. Explosive strength variables included flight time, jump height, peak force, instantaneous forces, and rates of force development. Data were analyzed using Bonferroni adjusted paired t-tests. RESULTS: VS had statistically increased flexibility (P) and large effect sizes (d) in both the RFS (P = 1.28 x 10(-7), d = 0.67) and LFS (P = 2.35 x 10(-7), d = 0.72). VS had statistically different results of favored (FL) (P = 4.67 x 10(-8), d= 0.78) and nonfavored (NFL) (P = 7.97 x 10(-10), d = 0.65) legs. VF resulted in statistical increases in flexibility and medium d on RFS (P = 6.98 x 10(-3), d = 0.25) and statistically increased flexibility on VF NFL flexibility (P = 0.002, d = 0.31). SF had no statistical difference between measures and small d. For explosive strength, there were no statistical differences in variables in the VS, SES, and VES for the pre- versus posttreatment tests. CONCLUSIONS: Simultaneous vibration and stretching may greatly increase flexibility while not altering explosive strength.

Kistler, B. M., M. S. Walsh, et al. (2010). "The acute effects of static stretching on the sprint performance of collegiate men in the 60- and 100-m dash after a dynamic warm-up." J Strength Cond Res **24**(9): 2280-2284.

Previous research has shown that static stretching has an inhibitory effect on sprinting performances up to 50 m. The purpose of this study was to see what would happen to these effects at longer distances such as those seen in competition. This study used a within-subjects design to investigate the effects of passive static stretching vs. no stretching on the 60- and 100-m sprint performance of college track athletes after a dynamic warm-up. Eighteen male subjects completed both the static stretching and the no stretching conditions in counterbalanced order across 2 days of testing. On each day, all subjects first completed a generalized dynamic warm-up routine that included a self-paced 800-m run, followed by a series of dynamic movements, sprint, and hurdle drills. At the end of this generalized warm-up, athletes were assigned to either a static stretching or a no-stretching condition. They then immediately performed 2 100-m trials with timing gates set up at 20, 40, 60, and 100 m. Results revealed a significant slowing in performance with static stretching ($p < 0.039$) in the second 20 (20-40) m of the sprint trials. After the first 40 m, static stretching exhibited no additional inhibition of performance in a 100-m sprint. However, although there was no additional time loss, athletes never gained back the time that was originally lost in the first portion of the trials. Therefore, in strict terms of performance, it seems harmful to include static stretching in the warm-up protocol of collegiate male sprinters in distances up to 100 m.

Kokkonen, J., A. G. Nelson, et al. (2010). "Early-phase resistance training strength gains in novice lifters are enhanced by doing static stretching." J Strength Cond Res **24**(2): 502-506.

This study investigated differences in lower-body strength improvements when using standard progressive resistance training (WT) vs. the same progressive resistance training combined with static stretching exercises (WT + ST). Thirty-two college students (16 women and 16 men) were pair matched according to sex and knee extension 1 repetition maximum (1RM). One person from each pair was randomly assigned to WT and the other to WT + ST. WT did 3 sets of 6 repetitions of knee extension, knee flexion, and leg press 3 days per week for 8 weeks with weekly increases in the weight lifted. The WT + ST group performed the same lifting

program as the WT group along with static stretching exercises designed to stretch the hip, thigh, and calf muscle groups. Stretching exercise sessions were done twice a week for 30 minutes during the 8-week period. WT significantly ($p < 0.05$) improved their knee flexion, knee extension, and leg press 1RM by 12, 14, and 9%, respectively. WT + ST, on the other hand, significantly ($p < 0.05$) improved their knee flexion, knee extension, and leg press 1RM by 16, 27, and 31, respectively. In addition, the WT + ST group had significantly greater knee extension and leg press gains ($p < 0.05$) than the WT group. Based on results of this study, it is recommended that to maximize strength gains in the early phase of training, novice lifters should include static stretching exercises to their resistance training programs.

McHugh, M. P. and C. H. Cosgrave (2010). "To stretch or not to stretch: the role of stretching in injury prevention and performance." Scand J Med Sci Sports **20**(2): 169-181.

Stretching is commonly practiced before sports participation; however, effects on subsequent performance and injury prevention are not well understood. There is an abundance of literature demonstrating that a single bout of stretching acutely impairs muscle strength, with a lesser effect on power. The extent to which these effects are apparent when stretching is combined with other aspects of a pre-participation warm-up, such as practice drills and low intensity dynamic exercises, is not known. With respect to the effect of pre-participation stretching on injury prevention a limited number of studies of varying quality have shown mixed results. A general consensus is that stretching in addition to warm-up does not affect the incidence of overuse injuries. There is evidence that pre-participation stretching reduces the incidence of muscle strains but there is clearly a need for further work. Future prospective randomized studies should use stretching interventions that are effective at decreasing passive resistance to stretch and assess effects on subsequent injury incidence in sports with a high prevalence of muscle strains.

Mojock, C. D., J. S. Kim, et al. (2011). "The effects of static stretching on running economy and endurance performance in female distance runners during treadmill running." J Strength Cond Res **25**(8): 2170-2176.

Stretching can lead to decreased muscle stiffness and has been associated with decreased force and power production. The purpose of this study was to investigate the acute effects of static stretching (SS) on running economy and endurance performance in trained female distance runners. Twelve long distance female (30 +/- 9 years) runners were assessed for height (159.4 +/- 7.4 cm), weight (54.8 +/- 7.2 kg), % body fat (19.7 +/- 2.8%), and maximal oxygen consumption (VO2max: 48.4 +/- 5.1 ml.kg(-1).min(-1)). Participants performed 2 sessions of 60-minute

treadmill runs following a randomly assigned SS protocol or quiet sitting (QS). During the first 30 minutes (running economy), expired gases, heart rate (HR), and rating of perceived exertion (RPE) were recorded while the participant ran at 65% VO2max. During the final 30 minutes (endurance performance), distance covered, speed, HR, and RPE were recorded while the participant attempted to cover as much distance as possible. Repeated measures analyses of variance were performed on the data. Significance was accepted at $p < 0.05$. The SS measured by sit-and-reach increased flexibility (SS: 29.8 +/- 8.3 vs. QS: 33.1 +/- 8.1 cm) but had no effect on running economy (VO2: 33.7 +/- 3.2 vs. 33.8 +/- 2.3 ml.kg(-1).min(-1)), calorie expenditure (270 +/- 41 vs. 270 +/- 41 kcal), HR (157 +/- 10 vs. 160 +/- 12 b.min(-1)), or endurance performance (5.5 +/- 0.6 vs. 5.5 +/- 0.7 km). These findings indicated that stretching did not have an adverse effect on endurance performance in trained women. This suggests that the performance decrements previously associated with stretching may not occur in trained women.

Morais de Oliveira, A. L., C. C. Greco, et al. (2012). "The rate of force development obtained at early contraction phase is not influenced by active static stretching." J Strength Cond Res **26**(8): 2174-2179.

ABSTRACT: Morais de Oliveira, AL, Coelho Greco, C, Molina, R, and Denadai, BS. The rate of force development obtained at early contraction phase is not influenced by active static stretching. J Strength Cond Res 26(8): 2174-2179, 2012-The objective of this study was to investigate the influence of active static stretching on the maximal isometric muscle strength (maximal voluntary contraction [MVC]) and rate of force development (RFD) determined within time intervals of 30, 50, 100, and 200 milliseconds relative to the onset of muscle contraction. Fifteen men (aged 21.3 +/- 2.4 years) were submitted on different days to the following tests: (a) familiarization session to the isokinetic dynamometer; (b) 2 maximal isometric contractions for knee extensors in the isokinetic dynamometer to determine MVC and RFD (control); and (c) 2 active static stretching exercises for the dominant leg extensors (10 x 30 seconds for each exercise with a 20-second rest interval between bouts). After stretching, the isokinetic test was repeated (poststretching). Conditions 2 and 3 were performed in random order. The RFD was considered as the mean slope of the moment-time curve at time intervals of 0-30, 0-50, 0-100; 0-150; and 0200 milliseconds relative to the onset of muscle contraction. The MVC was reduced after stretching (285 +/- 59 vs. 271 +/- 56 N.m, $p < 0.01$). The RFD at intervals of 0-30, 0-50, and 0-100 milliseconds was unchanged after stretching ($p > 0.05$). However, the RFD measured at intervals of 0-150 and 0-200 milliseconds was significantly lower after stretching ($p < 0.01$). It can be concluded that explosive muscular actions of a very short duration (<100 milliseconds) seem less affected by active static stretching when compared with actions using maximal muscle strength.

Morton, S. K., J. R. Whitehead, et al. (2011). "Resistance training vs. static stretching: effects on flexibility and strength." J Strength Cond Res **25**(12): 3391-3398.

Morton, SK, Whitehead, JR, Brinkert, RH, and Caine, DJ. Resistance training vs. static stretching: Effects on flexibility and strength. J Strength Cond Res 25(12): 3391-3398, 2011-The purpose of this study was to determine how full-range resistance training (RT) affected flexibility and strength compared to static stretching (SS) of the same muscle-joint complexes in untrained adults. Volunteers (n = 25) were randomized to an RT or SS training group. A group of inactive volunteers (n = 12) served as a convenience control group (CON). After pretesting hamstring extension, hip flexion and extension, shoulder extension flexibility, and peak torque of quadriceps and hamstring muscles, subjects completed 5-week SS or RT treatments in which the aim was to stretch or to strength train the same muscle-joint complexes over similar movements and ranges. Posttests of flexibility and strength were then conducted. There was no difference in hamstring flexibility, hip flexion, and hip extension improvement between RT and SS, but both were superior to CON values. There were no differences between groups on shoulder extension flexibility. The RT group was superior to the CON in knee extension peak torque, but there were no differences between groups on knee flexion peak torque. The results of this preliminary study suggest that carefully constructed full-range RT regimens can improve flexibility as well as the typical SS regimens employed in conditioning programs. Because of the potential practical significance of these results to strength and conditioning programs, further studies using true experimental designs, larger sample sizes, and longer training durations should be conducted with the aim of confirming or disproving these results.

O'Hora, J., A. Cartwright, et al. (2011). "Efficacy of static stretching and proprioceptive neuromuscular facilitation stretch on hamstrings length after a single session." J Strength Cond Res **25**(6): 1586-1591.

A number of studies have investigated the efficacy of several repetitions of proprioceptive neuromuscular facilitation stretching (PNF) and static stretching (SS). However, there is limited research comparing the effects of a single bout of these stretching maneuvers. The aim of this study was to compare the effectiveness of a single bout of a therapist-applied 30-second SS vs. a single bout of therapist-applied 6-second hamstring (agonist) contract PNF. Forty-five healthy subjects between the ages of 21 and 35 were randomly allocated to 1 of the 2 stretching groups or a control group, in which no stretching was received. The flexibility of the hamstring was determined by a range of passive knee extension, measured using a universal goniometer, with the subject in the supine position and the hip at 90 degrees flexion, before and after intervention. A significant increase in knee extension was found for both intervention groups after a single stretch (SS group = 7.53 degrees , $p < 0.01$ and PNF group = 11.80 degrees , $p < 0.01$). Both interventions resulted in a significantly greater increase in knee extension when compared to the control group ($p < 0.01$). The PNF group demonstrated significantly greater gains in knee extension compared to the SS group (mean difference 4.27 degrees , $p < 0.01$). It can be concluded that a therapist applied SS or PNF results in a significant increase in hamstring flexibility. A hamstring (agonist) contract PNF is more effective than an SS in a single stretching session. These findings are important to physiotherapists or trainers working in clinical and sporting environments. Where in the past therapists may have spent time conducting multiple repetitions of a PNF and an SS, a single bout of either technique may be considered just as effective. A key component of the study methodology was the exclusion of a warm-up period before stretching. Therefore, the findings of efficacy of a single PNF are of particular relevance in sporting environments and busy clinical settings where time may be limited.

Perrier, E. T., M. J. Pavol, et al. (2011). "The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility." J Strength Cond Res **25**(7): 1925-1931.

The purpose of this research was to compare the effects of a warm-up with static vs. dynamic stretching on countermovement jump (CMJ) height, reaction time, and low-back and hamstring flexibility and to determine whether any observed performance deficits would persist throughout a series of CMJs. Twenty-one recreationally active men (24.4 +/- 4.5 years) completed 3 data collection sessions. Each session included a 5-minute treadmill jog followed by 1 of the stretch treatments: no stretching (NS), static stretching (SS), or dynamic stretching (DS). After the jog and stretch treatment, the participant performed a sit-and-reach test. Next, the participant completed a series of 10 maximal-effort CMJs, during which he was asked to jump as quickly as possible after seeing a visual stimulus (light). The CMJ height and reaction time were determined from measured ground reaction forces. A treatment x jump repeated-measures analysis of variance for CMJ height revealed a significant main effect of treatment ($p = 0.004$). The CMJ height was greater for DS (43.0 cm) than for NS (41.4 cm) and SS (41.9 cm) and was not less for SS than for NS. Analysis also revealed a significant main effect of jump ($p = 0.005$) on CMJ height: Jump height decreased from the early to the late jumps. The analysis of reaction time showed no significant effect of treatment. Treatment had a main effect ($p < 0.001$) on flexibility, however. Flexibility was greater after both

SS and DS compared to after NS, with no difference in flexibility between SS and DS. Athletes in sports requiring lower-extremity power should use DS techniques in warm-up to enhance flexibility while improving performance.

Pope, R. P., R. D. Herbert, et al. (2000). "A randomized trial of preexercise stretching for prevention of lower-limb injury." Med Sci Sports Exerc **32**(2): 271-277.

PURPOSE: This study investigated the effect of muscle stretching during warm-up on the risk of exercise-related injury. METHODS: 1538 male army recruits were randomly allocated to stretch or control groups. During the ensuing 12 wk of training, both groups performed active warm-up exercises before physical training sessions. In addition, the stretch group performed one 20-s static stretch under supervision for each of six major leg muscle groups during every warm-up. The control group did not stretch. RESULTS: 333 lower-limb injuries were recorded during the training period, including 214 soft-tissue injuries. There were 158 injuries in the stretch group and 175 in the control group. There was no significant effect of preexercise stretching on all-injuries risk (hazard ratio [HR] = 0.95, 95% CI 0.77-1.18), soft-tissue injury risk (HR = 0.83, 95% CI 0.63-1.09), or bone injury risk (HR = 1.22, 95% CI 0.86-1.76). Fitness (20-m progressive shuttle run test score), age, and enlistment date all significantly predicted injury risk (P < 0.01 for each), but height, weight, and body mass index did not. CONCLUSION: A typical muscle stretching protocol performed during preexercise warm-ups does not produce clinically meaningful reductions in risk of exercise-related injury in army recruits. Fitness may be an important, modifiable risk factor.

Samogin Lopes, F. A., E. M. Menegon, et al. (2010). "Is acute static stretching able to reduce the time to exhaustion at power output corresponding to maximal oxygen uptake?" J Strength Cond Res **24**(6): 1650-1656.

This study analyzed the effect of an acute static stretching bout on the time to exhaustion (Tlim) at power output corresponding to VO2max. Eleven physically active male subjects (age 22.3+/-2.8 years, VO2max 2.7+/-0.5 L.min) completed an incremental cycle ergometer test, 2 muscle strength tests, and 2 maximal tests to exhaustion at power output corresponding to VO2max with and without a previous static stretching bout. The Tlim was not significantly affected by the static stretching (164+/-28 vs. 150+/-26 seconds with and without stretching, respectively, p=0.09), but the time to reach VO2max (118+/-22 vs. 102+/-25 seconds), blood-lactate accumulation immediately after exercise (10.7+/-2.9 vs. 8.0+/-1.7 mmol.L), and oxygen deficit (2.4+/-0.9 vs. 2.1+/-0.7 L) were significantly reduced (p<or=0.02). Thus, an acute static stretching bout did not reduce Tlim at power output corresponding to VO2max possibly by

accelerating aerobic metabolism activation at the beginning of exercise. These results suggest that coaches and practitioners involved with aerobic dependent activities may use static stretching as part of their warm-up routines without fear of diminishing high-intensity aerobic exercise performance.

Siatras, T. A., V. P. Mittas, et al. (2008). "The duration of the inhibitory effects with static stretching on quadriceps peak torque production." J Strength Cond Res **22**(1): 40-46.

Although several studies have investigated the acute effect of static stretching exercises, the duration of exercises that negatively affects performance has not been ascertained. This study was conducted to determine the acute effect of different static stretching durations on quadriceps isometric and isokinetic peak torque production. The 50 participants were randomly allocated into five equivalent sized groups and were asked to perform a stretching exercise of different duration (no stretch, 10-second stretch, 20-second stretch, 30-second stretch, and 60-second stretch). The knee flexion range of motion and the isometric and concentric isokinetic peak torques of the quadriceps were measured before and after a static stretching exercise in the four experimental groups. The same parameters were examined in the control group (no stretch) without stretching, before and after a 5-minute passive rest. There were no significant differences among groups before the experimentation regarding their physical characteristics and performances ($P > 0.05$). These results reflect the different groups' homogeneity. Significant knee joint flexibility increases ($P < 0.001$) and significant isometric and isokinetic peak torque reductions ($P < 0.05$-0.001) have been shown to occur only after 30 and 60 seconds of quadriceps static stretching. Stretching reduced isometric peak torque by 8.5% and 16.0%, respectively. Concerning isokinetic peak torque after 30 and 60 seconds of stretching, it was reduced by 5.5% vs. 11.6% at 60 degrees/s and by 5.8% vs. 10.0% at 180 degrees/s. We suggest that torque decrements are related to changes of muscle neuromechanical properties. It is recommended that static stretching exercises of a muscle group for more than 30 seconds of duration be avoided before performances requiring maximal strength.

Simic, L., N. Sarabon, et al. (2012). "Does pre-exercise static stretching inhibit maximal muscular performance? A meta-analytical review." Scand J Med Sci Sports.

We applied a meta-analytical approach to derive a robust estimate of the acute effects of pre-exercise static stretching (SS) on strength, power, and explosive muscular performance. A computerized search of articles published between 1966 and December 2010 was performed using PubMed, SCOPUS, and Web of Science databases. A total of 104 studies

yielding 61 data points for strength, 12 data points for power, and 57 data points for explosive performance met our inclusion criteria. The pooled estimate of the acute effects of SS on strength, power, and explosive performance, expressed in standardized units as well as in percentages, were -0.10 [95% confidence interval (CI): -0.15 to -0.04], -0.04 (95% CI: -0.16 to 0.08), and -0.03 (95% CI: -0.07 to 0.01), or -5.4% (95% CI: -6.6% to -4.2%), -1.9% (95% CI: -4.0% to 0.2%), and -2.0% (95% CI: -2.8% to -1.3%). These effects were not related to subject's age, gender, or fitness level; however, they were more pronounced in isometric vs dynamic tests, and were related to the total duration of stretch, with the smallest negative acute effects being observed with stretch duration of </=45 s. We conclude that the usage of SS as the sole activity during warm-up routine should generally be avoided.

THACKER, S. B., J. GILCHRIST, et al. (2004). "The Impact of Stretching on Sports Injury Risk: A Systematic Review of the Literature." Medicine & Science in Sports & Exercise **36**(3): 371-378.

THACKER, S. B., J. GILCHRIST, D. F. STROUP, and C. D. KIMSEY, JR. The Impact of Stretching on Sports Injury Risk: A Systematic Review of the Literature. Med. Sci. Sports Exerc., Vol. 36, No. 3, pp. 371-378, 2004. Purpose: We conducted a systematic review to assess the evidence for the effectiveness of stretching as a tool to prevent injuries in sports and to make recommendations for research and prevention. Methods: Without language limitations, we searched electronic data bases, including MEDLINE (1966-2002), Current Contents (1997-2002), Biomedical Collection (1993-1999), the Cochrane Library, and SPORTDiscus, and then identified citations from papers retrieved and contacted experts in the field. Meta-analysis was limited to randomized trials or cohort studies for interventions that included stretching. Studies were excluded that lacked controls, in which stretching could not be assessed independently, or where studies did not include subjects in sporting or fitness activities. All articles were screened initially by one author. Six of 361 identified articles compared stretching with other methods to prevent injury. Data were abstracted by one author and then reviewed independently by three others. Data quality was assessed independently by three authors using a previously standardized instrument, and reviewers met to reconcile substantive differences in interpretation. We calculated weighted pooled odds ratios based on an intention-to-treat analysis as well as subgroup analyses by quality score and study design. Results: Stretching was not significantly associated with a reduction in total injuries (OR = 0.93, CI 0.78-1.11) and similar findings were seen in the subgroup analyses. Conclusion: There is not sufficient evidence to endorse or discontinue routine stretching before or after exercise to prevent injury among competitive or recreational athletes. Further research, especially well-

conducted randomized controlled trials, is urgently needed to determine the proper role of stretching in sports. (C)2004The American College of Sports Medicine

Wilson, J. M., L. M. Hornbuckle, et al. (2010). "Effects of static stretching on energy cost and running endurance performance." J Strength Cond Res **24**(9): 2274-2279.

Stretching before anaerobic events has resulted in declines in performance; however, the immediate effects of stretching on endurance performance have not been investigated. This study investigated the effects of static stretching on energy cost and endurance performance in trained male runners. Ten trained male distance runners aged 25 +/- 7 years with an average VO2max of 63.8 +/- 2.8 ml/kg/min were recruited. Participants reported to the laboratory on 3 separate days. On day 1, anthropometrics and VO2max were measured. On days 2 and 3, participants performed a 60-minute treadmill run randomly under stretching or nonstretching conditions separated by at least 1 week. Stretching consisted of 16 minutes of static stretching using 5 exercises for the major lower body muscle groups, whereas nonstretching consisted of 16 minutes of quiet sitting. The run consisted of a 30-minute 65% VO2max preload followed by a 30-minute performance run where participants ran as far as possible without viewing distance or speed. Total calories expended were determined for the 30-minute preload run, whereas performance was measured as distance covered in the performance run. Performance was significantly greater in the nonstretching (6.0 +/- 1.1 km) vs. the stretching (5.8 +/- 1.0 km) condition ($p < 0.05$), with significantly greater energy expenditure during the stretching compared with the nonstretching condition (425 +/- 50 vs. 405 +/- 50 kcals). Our findings suggest that stretching before an endurance event may lower endurance performance and increase the energy cost of running.

Yamaguchi, T., K. Ishii, et al. (2006). "Acute effect of static stretching on power output during concentric dynamic constant external resistance leg extension." J Strength Cond Res **20**(4): 804-810.

The purpose of the present study was to clarify the effect of static stretching on muscular performance during concentric isotonic (dynamic constant external resistance [DCER]) muscle actions under various loads. Concentric DCER leg extension power outputs were assessed in 12 healthy male subjects after 2 types of pretreatment. The pretreatments included (a) static stretching treatment performing 6 types of static stretching on leg extensors (4 sets of 30 seconds each with 20-second rest periods; total duration 20 minutes) and (b) nonstretching treatment by resting for 20 minutes in a sitting position. Loads during assessment of the

power output were set to 5, 30, and 60% of the maximum voluntary contractile (MVC) torque with isometric leg extension in each subject. The peak power output following the static stretching treatment was significantly ($p < 0.05$) lower than that following the nonstretching treatment under each load (5% MVC, 418.0 +/- 82.2 W vs. 466.2 +/- 89.5 W; 30% MVC, 506.4 +/- 82.8 W vs. 536.4 +/- 97.0 W; 60% MVC, 478.6 +/- 77.5 W vs. 523.8 +/- 97.8 W). The present study demonstrated that relatively extensive static stretching significantly reduces power output with concentric DCER muscle actions under various loads. Common power activities are carried out by DCER muscle actions under various loads. Therefore, the result of the present study suggests that relatively extensive static stretching decreases power performance.