A critical review on the acute effects of various stretching methods on performance

Dan Pratt, MSc, BSc (Hons), PGCE, ASCC / *Wellington College, Berkshire*

OVERVIEW

It has become standard practice in most, if not all, major sports to perform a warm-up of a dynamic nature and to avoid the use of static stretching methods. The following article will aim to provide a review of available research into the acute effects of commonly used pre-performance stretching protocols. In addition, this article will also provide a brief review of the physiological factors influencing the decision-making process when selecting pre-performance warm-up and stretching practices in order to provide practical guidelines on pre-performance stretching protocols.

Introduction

Flexibility, when related to human movement, is defined as the range of movement (ROM) at a given joint, which can be both active and dynamic in nature, depending on whether it is under muscular control (active) or if it is under the control of external forces (passive).[1,60,119] Ergan[35] suggests that stretching may have first been used by the ancient Greeks and across Asia, with modern day uses being related to athletic performance, improved health and injury prevention.[1,33,39,47,48,55] A number of stretching methods have now evolved, with those most often utilised detailed in Table 1.[1,70,119]

Research into the use of stretching and warm-ups for athletic performance is known to have begun in the 1930s[121] and to date it has been suggested that the main acute benefits of stretching for athletic performance are to increase performance and to reduce the risk of injury.[41,42,94,95,115,137] These acute benefits to performance are believed to occur due to a number of factors, such as an increase in the range of movement at joints, enhanced muscular coordination and a reduction in muscular resistance to movement.[70, 117, 122]

However, it is also argued that there is a lack of clarity in the pre-performance stretching literature and that coaches often base their decisions on personal experiences.[42,74,104,122] Many strength and conditioning (S&C) coaches currently avoid the use of static stretching (SS) protocols prior to performance and focus on dynamic stretching (DS),[31,72] probably

Table 1: Stretching methods

Static stretching (SS)	This involves acquiring a posture and slowly stretching a limb towards the end of its range of movement, either actively or passively
Ballistic stretching (BS)	This involves similar postures to those seen in static stretching: however, it involves bouncing at the end range of movement
Dynamic stretching (DS)	This involves stretching muscles actively through functional ranges
Proprioceptive neuromuscular facilitation (PNF)	This involves cycles of contracting, relaxing and stretching a muscle.

AUTHOR'S BIO

DAN PRATT, MSC, BSC (HONS), PGCE, ASCC

Dan is the lead strength and conditioning coach at Wellington College, Berkshire and also with the Surrey County Cricket Club Academy and Emerging Players Program. Dan has been involved in the S&C profession since 2007, specialising in working with youth athletes. Dan also teaches physical education at Wellington College.

due to the much publicised view that SS acutely reduces performance levels and only has minimal benefits, if any, on reducing injury risk.[50,100,117,122] It is common now to observe athletes, prior to performance, being made to complete an aerobic warm-up, followed by DS, and finally by a sport-specific warm-up element.[125, 126]

Despite the overall focus of coaches on DS, it should not however be overlooked that in sports where an extreme ROM is required, such as gymnastics or sprint hurdling, static stretching protocols may still benefit performance by increasing the ROM available at joints.[55] As previously suggested, coaches' practices are likely to be guided by the fact that there does appear to be an overall theme: ie, that the use of SS,[5, 13, 44, 50, 59, 73, 82, 85, 89, 90, 100, 101, 106, 126, 131, 136, 142] ballistic stretching (BS),[108] and proprioceptive neuromuscular facilitation (PNF)[16,99] stretching all acutely reduce performance levels in strength and power tasks, whereas DS has the ability to enhance strength and power performance.[2, 65, 80, 82, 136] However, there is also conflicting research which has not observed these general themes in response to stretching protocols. This is probably caused due to differences in the volume and intensity of stretching and also the use of additional pre-performance warm-up strategies: this research must also be considered before choosing what stretching protocols to utilise.[10, 19, 27, 46, 71, 86, 87, 90, 128, 129, 137]

The importance of volume

With regards to the volume of stretching, it would appear that those studies finding no negative effects of SS, PNF and BS have often used a lower volume of stretching compared to those finding a negative effect.[10, 19, 129, 130] For example, Torres et al,[129] Unick et al[130] and Knudson et al[77] all used a low volume of 2-3 sets of stretches, held for 15 seconds, and observed no effects of stretching on strength or power performance or on the accuracy or speed of a tennis serve. Furthermore, Christensen and Nordstrom[19] also found that three sets of a PNF protocol of less than 10 seconds had no effects on CMJ (countermovement jump) heights and neither did a low volume lower limb DS, of one set of five repetitions.

However, it should be noted that many studies assessing lower volumes of stretching often did not assess if ROM was improved and as a major outcome of stretching is to enhance ROM, it may be that these lower volume stretching protocols have a limited effect on ROM too.[12,19,76,80,88,129,130]

It has also been observed, in those studies noting negative effects following SS, BS or PNF or positive effects following DS, that relatively high volumes of stretching, with 2 to 6 stretches of 3 to 8 sets of 30 to 60 repetitions or seconds have been used.[13, 20, 22, 25, 57, 63, 65, 78, 79, 80, 84, 94, 104]

The influence of the volume of stretching has been directly studied by a number of authors, who have found that SS protocols of a greater volume, via increased time under stretch (>30 s) or a higher number of sets (>2), have a greater detrimental effect on strength and power performance, although it must be noted that these studies used relatively untrained subjects whom the authors argue may respond differently compared to well-trained athletes.[98, 106, 118, 142] However, Evetovich et al[37] observed that both trained and untrained athletes responded with similar reductions in knee extension torque following a SS protocol.

Although the volume of stretching appears to play a key role in the subsequent strength and power performance, Brandenburg[17] observed similar decreases in hamstring maximum voluntary isometric contraction (MVIC) following SS of 15 and 30 s. Furthermore, in a recent study by Molacek et al,[91] it was suggested that neither higher volumes of PNF or SS significantly reduced 1RM (repetition maximum) bench press. However, these studies do not eliminate the possibility that a stretch duration of greater than 30 s may still be detrimental to performance; but rather they highlight that other variables may also be important within stretching protocols.

The importance of intensity

Both Brandenburg[17] and Molacek et al[91] used stretching intensities of moderate levels, which may explain the lack of effect of increasing stretch volume in these studies, as those observing reduced strength and power performance have often used stretching intensities to a point of pain.[79,95,104,118] However, Behm and Kibele[14] assessed the effects of SS at three different intensities, including 50%, 75% and 100% of the maximum level of discomfort, on VJ (vertical jump) heights, and found that irrespective of stretch intensity, VJ performance was reduced by around 4%. However, it is likely that the inexperienced athletic background of the subjects in this study meant they were unable to accurately establish the point of 100% discomfort – or that this point differed subjectively between individuals, which caused a lack of standardisation in stretch intensities.

Table 2: Abbreviations referring to testing protocols

Countermovement jump (CMJ) and squat jump (SJ)	An assessment of lower limb power usually with hands on hips, with the aim being to either dip and jump as high as possible (CMJ) or start from a squat depth and jump as high as possible (SJ)
Maximum voluntary isometric contraction (MVIC) and maximum voluntary contraction (MVC)	An assessment method used to understand voluntarily produced maximum force output, usually of a given muscle group or in a given movement, in either a static or dynamic exercise
Repetition maximum (RM)	An assessment of the maximum load that can be lifted in a given exercise for a given number of repetitions
Vertical jump (VJ)	For the purpose of this article VJ refers to a number of methods of vertical jumping that have been used across research studies, including, countermovement jumps, squat jumps and drop jumps

Whether stretches – and in particular SS – are done actively or passively could also affect their outcomes on performance, as there may be a lag between the stretch level aimed for and subjective acknowledgment of this level. Passive stretching in research has often been achieved through the use of machines, which may standardise the force applied but will lack any subtle control and could cause increased stretch intensities, possibly explaining why some research has seen decreases in plantar flexor maximum voluntary contractions (MVC) as great as 20%.[5,6,40] In addition, many of these studies also used extreme stretching volumes of 30 minutes to an hour, which – as highlighted previously – will also contribute to the large reduction in plantar-flexor MVC observed.[5,6,40]

The importance of stretching intensity may also be seen with regards to DS, as those studies observing performance enhancement following DS have often used a protocol that encourages task-specific speeds of DS, which may better prepare athletes for performance.[65,68] It may be that the intensity of the active warm-up element and the DS are vital if they are to aid performance: Fletcher and Jones[38] found significantly improved sprint times when identical DS stretches were performed while moving forwards as compared to on the spot, which the authors suggest may be an effect of the active DS providing a more sprint-specific coordinated warm-up.

The effect of a general warm-up phase

A major confounding factor in much of the acute stretching research is the use of additional warm-up procedures, such as sport skill practices, light aerobic activities and/or the use of warm-up sets of the assessment task.[12,19,20,43,91] Interestingly, it appears that those studies utilising an additional warm-up element, combined with a lower volume of stretching generally, show minimal influences of SS, PNF, BS or DS methods on the subsequent performance.[10,19,30] The pre-performance combination of an active warm-up or DS and a static stretching element may be argued to negate any potential negative effects, as it has been observed that SS had no negative effects on VJ heights, baseball pitching speeds or 100 metre sprinting when combined with DS and or an aerobic warm-up element.[58,74,132]

When combining pre-performance strategies what may be important is in what order these elements are conducted, as research has found that performing SS following DS, or an active warm-up, may lead to reduced repeat sprint ability and sprint speeds and therefore this presents itself as another variable for coaches to consider.[18, 120]

Although it does appear that an active warm-up, and/or DS protocol, may have the ability to off set detrimental effects of SS protocols, it may also be that when the sports skill in question requires relatively fine motor control – such as a golf swing – that SS protocols still lead to reduced performance in terms of accuracy and distance of shot, irrelevant of the order in which stretching protocols are conducted.[48,49] However, these results may be limited, as subjects were young (<18 years) and may still have been refining their movement control patterns.[48,49] Where active warm-ups or DS are used, it is important that they do not lead to fatigue, as Reiman et al[105] found a decrease in a stair climbing test, albeit non-significant, following a weighted DS, which is likely to have occurred due to fatigue. This indicates that, in addition to other variables, coaches must consider the current training status of subjects when prescribing pre-performance preparation strategies.

Effects on endurance performance

Similarly to strength and power performance it seems that with higher volumes of stretching, the reductions in muscular endurance performance increase;[43] however, research assessing stretching and muscular endurance has only examined performance with loads from 50-85% 1RM and it may be that with lighter loads, such as body weight, there may be less of a reduction in performance levels due to the reduced intensity of performance.[43,45,53,96] With regards to aerobic performance and the acute effects of stretching, the current research is fairly limited and shows equivocal results,[61, 90] with Hayes and Walker[61] – in a study of only seven subjects – concluding that neither SS nor DS had any significant

Stretching may have been first used by the ancient Greeks

effect on running economy or oxygen uptake. However, Wilson et al[135] and Lowery et al[82] respectively found that SS significantly increased energy expenditure and reduced the total distance covered during treadmill running and also increased one-mile uphill running times. The differing results observed in these studies may be due to the fact that Lowery et al[82] assessed performance while running on an incline, which may stress the importance of the elastic component of the lower limbs, and Wilson et al[135] assessed performance in a 60-min run, whereas Hayes and Walker[61] used only a 10-min run, during which they did not assess total distance covered. Had Hayes and Walker[61] used a longer duration run and assessed the distance covered, they may well have observed alterations in running economy or oxygen uptake. It is also of note that Godges et al[52] observed an improved running gait following SS and PNF, which may indicate an enhanced running economy but this requires further research.

Striking a balance

As research would seem to suggest that high volumes and intensities of static stretching protocols which are not combined with DS or an active warm-up reduce performance, it is likely that coaches will avoid the use of static stretching protocols in this way.[72] However, where ROM is highly sought after for performance, as in gymnastics,[55] this may not be possible.

Therefore, it may be that coaches will look to balance the effects of gains in ROM and potential decreases in performance levels, suggesting it is important to understand the duration over which performance may be reduced and ROM increased. Following four sets of 30 seconds of SS, hamstrings ROM has been seen to be increased for up to six minutes, with a non-significant increase in ROM remaining for around 30 minutes.[32, 123] In comparison, research which notes reduced performance levels following SS appear to observe this occurring for up to 16 minutes, with the greatest declines in performance seen in the first five minutes.[5, 16, 86, 89] However, it should also be noted that SS has been seen to limit performance for up to 24 hours in 30 m sprint, repeated jumps and repeated sprints, albeit with 15-minute stretching durations.[59] The time span of five minutes also seems important in terms of achieving peak performance following DS, as peak CMJ heights have been noted to occur five minutes after a DS protocol; however, this study also utilised an extensive active warm-up, which may have increased the speed with which the positive effects of DS were seen.[29]

Physiology of stretching

A number of factors have been identified to limit flexibility, including: structural limitations, mechanical properties, neuromuscular control and an individual's pain threshold.[1,119] The two main mechanisms that probably underpin the acute stretching induced alterations in performance are suggested to be either neuromuscular or mechanical factors.[109,114,141] Research which has observed static stretching protocols to reduce performance has often noted reduced electromyography (EMG) levels or Hoffmann reflex (H-reflex) results, which are used to identify a reduction in neural activation of motor units and reflex activity.[5,6,11,26,40,84,86]

As previously highlighted, it appears that the duration of the stretching protocol influences the neural response to stretching, as Rossi et al[108] recently identified a larger EMG reduction following 60 s SS compared to 30 s. Muscular activation, as assessed via EMG, has also been seen to increase in response to DS, which may indicate that DS has the capability to enhance performance via improved muscular activation.[63,65] Additionally, DS may enhance performance via associated increases in metabolic processes due to increases in muscle and blood temperatures.[34,87]

DS aside, research appears to identify that static stretching (SS, BS and PNF) reduces reflex activities, as observed by blunted H-reflex responses; however, other authors argue that when assessing H-reflex activity the M-wave response is more important as a sign of early neural stimulation and that this is not seen to decrease.[5,6,24,133] This maintained M-wave response appears to identify that neural excitation and conduction velocity are not inhibited due to static stretching (SS, BS and PNF) protocols, although this may require further research. Any alterations in neuromuscular activation levels following static stretching methods are likely to be controlled via the feedback and subsequent stretch reflex inhibitions, which originate from Golgi tendon organs, muscle spindles and the various mechanoreceptors.[21,22,56,65,92,108]

The central nervous system may also influence changes in performance due to stretching, as Cramer et al[25] noted that isokinetic peak torque decreased in both stretched and un-stretched limbs. However, Avela et al[5] did not observe

'a number of research reviews and well-constructed meta-analyses conclude that pre-performance protective effect on injury risk'

decreases in peak torque production in stretched and un-stretched limbs, which may suggest the results observed by Cramer et al[25] were due to a general level of fatigue, as subjects were untrained. In support of a neuromuscular mechanism controlling performance alterations following stretching, it has been seen that reductions in EMG or H-reflex response are recovered after 5-15 minutes rest, which is the same time frame over which performance levels are seen to recover as well.[5, 40]

MECHANICAL LIMITATIONS

Aside from the neuromuscular limitations to flexibility, the mechanical limitations are defined by the overall structure of muscles and tendons.[1,119] Several authors argue that alterations in performance following stretching occur due to changes in stiffness, as increased energy costs of running following SS have been observed, which probably arise from a lack of return of elastic energy.[81, 135] However, it should not be overlooked that reduced muscular stiffness and enhanced compliance have also been suggested to aid performance by limiting resistance to movement.[117] Other authors have aimed to assess changes in muscular stiffness and compliance more directly, via the use of mechanomyography (MMG), which records the rate and number of oscillations on a surface.[26,36,63,84] Several of these authors observed increased MMG results following static stretching protocols, which may identify an alteration in muscle-tendon length and an increase in muscle slack, which may highlight a reduced muscular stiffness or an alteration in the cross-bridge formation processes.[25] A further mechanical mechanism potentially responsible for performance alterations following static stretching protocols is that of an increase in the muscle length-tension relationship, as often the knee angle at which the MVIC or the peak SJ height occurs increases following SS and PNF.[25,128] As the research appears to be equivocal in terms of the mechanisms causing stretch-induced declines in performance, it is most likely that a combination of both a neuromuscular and mechanical mechanism contribute to alterations in stretch-induced performance.

Injury reduction

A further acute benefit of stretching involves the possible role of stretching in relation to reducing injury risks.[110] The belief that stretching prior to performance can reduce injury risks is probably related to the theory of a 'non-injury zone' put forward by Woods et al,[138] which suggests that there is a range of movement that joints can move within safely. Research does suggest that reduced flexibility can lead to a 2.5x increased injury risk;[102] however, there are a number of research reviews and well-constructed meta-analyses which conclude that pre-performance stretching has little to no protective effect on injury risk.[3, 41, 51, 54, 62, 66, 116, 138] Importantly though, it must be recognized that research looking at stretching and injury risk has generally been retrospective and has often used non-sporting populations.[28, 103]

Despite methodological issues with the research looking at stretching and injury risk, it does appear that there are only very minimal benefits, if any, despite previous views of the injury-protective role of pre-performance stretching.[110]

Chronic stretching

Although this review has focused on the acute effects of stretching, it is important to acknowledge that chronic stretching programs have the ability to enhance flexibility, particularly where muscular tightness is present.[1,4,7,8] In addition, research has also found that including regular SS within a training program may have beneficial effects on sprint times and on CMJ heights.[31,67] However, in comparison, others have not observed any effects of stretching programmes on standing broad jump performance or CMJ height and in some cases it has been observed that before-session and in-session SS may actually limit gains in strength.[15,64,139] Many studies investigating the chronic effects of stretching may have limited external validity due to having only been conducted over short durations (~10 weeks). Intuitively, however, it would seem that – due to the acute declines in performance caused by static stretching – it is likely that the use of this method will limit chronic gains if done regularly before or during training. Therefore, this suggests that chronic stretching programmes should be performed some time before or after other training sessions.

Practical guidance

It would appear that those coaches who focus on DS and avoid static stretching methods (SS, BS and PNF) might well be reducing the chances of causing any decrease in performance due to the use of static stretching practices (SS, BS and PNF). However, it would also seem that low volume (1-2 sets), short duration (10-25 s) and moderate intensity static stretching methods (SS, BS and PNF) may not be detrimental to performance and may actually be beneficial where extreme ROMs are required.[55,129,130] Furthermore, it is likely that if a static-stretching based protocol is conducted prior to a subsequent active warm-up element, it will have limited detrimental effects on performance, particularly if the subsequent performance is at least 10-15 minutes after the stretching protocol.[16,58] An additional issue which may encourage the use of a static stretching protocol is that there may be a psychological benefit, especially if this has become a habitual element of an athlete's warm-up; removing this may therefore be detrimental to the overall performance preparation.[9] Finally, SS has also been found to enhance dynamic balance, which may occur due to an enhanced proprioceptive mechanism, offering a wider benefit to the athlete, such as an injury protective effect. However, it should be noted that any enhancement in balance is negated if the stretching exercises are held for longer than 30 s.[24]

Conclusion

In the field of modern day athletic performance it has been suggested that stretching has possible benefits over the longer and shorter term, including a possible role in the reduction of injury risks. This review has addressed the current avoidance of static stretching (SS, BS and PNF) protocols in pre-performance routines, due to fears of causing an acutely reduced performance. Having reviewed currently available research on pre-performance stretching, it is suggested that such fears may be overemphasised, providing the static stretching protocols used are of low volume (1-2 sets), short duration (10-25 s), moderate intensity and conducted at least 10-15 minutes prior to performance. Through following these guidelines, it is likely that neither mechanical nor neuromuscular mechanisms, which may be affected via stretching, will be altered significantly enough to have any detrimental impact on performance. This review does not suggest that static stretching protocols should replace the more active protocols currently used rather it advises that if static stretching protocols are to be used – for example in sports requiring enhanced ROM – they should be carried out prior to an active element and some time before performance, so as to reduce any fears over reductions in performance levels.

References

1. Alter, M J. Science of Flexibility (2nd ed.). Champaigne, IL: *Human Kinetics*. 1996.
2. Amiri-Khorasani, M, Osman, N A A, and Yusof, A. Acute effect of static and dynamic stretching on hip dynamic range of motion during instep kicking in professional soccer players. *Journal of Strength and Conditioning Research*, 25, 1647-1652. 2011.
3. Andersen, J C. Stretching before and after exercise: effect on muscle soreness and injury risk. *Journal of Athletic Training*, 40, 218-220. 2005.
4. Apostolopoulos, N. Performance Flexibility. In B Foran, High-Performance Sports Conditioning. Leeds: *Human Kinetics*. 2001. pp 49-62.
5. Avela, J, Kyrolainen, H, and Komi, PV. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. *Journal of Applied Physiology*, 86, 1283-1291. 1999.
6. Avela, J, Finni, T, Liikavainio, T, Niemela, E, and Komi, P V. Neural and mechanical responses of the triceps surae muscle group after 1h of repeated fast passive stretches. *Journal of Applied Physiology*, 96, 2325-2332. 2004.
7. Ayala, F, and Sainz de Baranda Andujar, P. Effect of 3 different active stretch duration on hip flexion range of motion. *Journal of Strength and Conditioning Research*, 24, 430-436. 2010.
8. Bandy, W D, Irion, J M, and Briggler, M. The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Physical Therapy*, 77, 1090-1096. 1997.
9. Beckett, J R, Schneiker, K T, Wallmann, K E, Dawson, B T, and Guelfi, K J. Effects of static stretching on repeated sprint and change of direction performance. *Medicine and Science in Sports and Exercise*, 41, 444-450. 2009.
10. Beedle, B, Rytter, S J, Healy, R C, and Ward, T R. Pretesting static and dynamic stretching does not affect maximal strength. *Journal of Strength and Conditioning Research*, 22, 1838-1843. 2008.
11. Behm, D G, Button, D C, and Butt, J C. Factors affecting force loss with prolonged stretching. *Canadian Journal of Applied Physiology*, 26, 262-272. 2001.
12. Behm, D G, Bambury, A, Cahill, F, and Power, K. Effect of acute static stretching on force, balance, reaction time, and movement time. *Medicine and Science in Sports and Exercise*, 36, 1397-1402. 2004.
13. Behm, D G, Bradbury, E E, Haynes, A T, Hodder, J N, Leonard, A M, and Paddock, NR. Flexibility is not related to stretch-induced deficits in force or power. *Journal of Sports Science and Medicine*, 5, 33-42. 2006.
14. Behm, D G, and Kibele, A. Effects of differing intensities of static stretching on jump performance. *European Journal of Applied Physiology*, 101, 587-594. 2007.
15. Borges Bastos, C L, Miranda, H, Vale, R G S, Portal, M D N, Gomes, T M, Novaes, J S, and Winchester, J B. Chronic effect of static stretching on strength performance and basal serum IGF-1 levels. *Journal of Strength and Conditioning Research*, 27(9): 2465-2472. 2013.
16. Bradley, P S, Olsen, P D, and Portas, M D. The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *Journal of Strength and Conditioning Research*, 21, 223-226. 2007.
17. Brandenburg, J P. Duration of stretch does not influence the degree of force loss following static stretching. *Journal of Sports Medicine and Physical Fitness*, 46, 526-534. 2006.
18. Chaouchi, A, Custagna, C, Chtara, M, Brughelli, M, Turki, O, Galy, O, Chamari, K, and Behm, D G. Effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals. *Journal of Strength and Conditioning Research*, 24, 2001-2011. 2010.
19. Christensen, B K, and Nordstrom, B J. The effects of proprioceptive neuromuscular facilitation and dynamic stretching techniques on vertical jump performance. *Journal of Strength and Conditioning Research*, 22, 1826-1831. 2008.
20. Church, J B, Wiggins, M S, Moode, F M, and Crist, R. Effect of warm-up and flexibility treatments on vertical jump performance. *Journal of Strength and Conditioning Research*, 15, 332-336. 2001.
21. Condon, S M, and Hutton, R S. Soleus muscle electromyographic activity and ankle dorsiflexion range of motion during four stretching procedures. *Physical Therapy*, 67, 24-30. 1987.
22. Cornwell, A, Nelson, A G, and Sidaway, B. Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. *European Journal of Applied Physiology*, 86, 428-434. 2002.
23. Costa, P B, Graves, B S, Whitehurst, M, and Jacobs, P L. The acute effects of different durations of static stretching on dynamic balance performance. *Journal of Strength and Conditioning Research*, 23, 141-147. 2009.
24. Costa, P B, Ryan, E D, Herda, T J, Walter, A A, Hoge, K M, and Cramer, J T. Acute effects of passive stretching on the electromechanical delay and evoked twitch properties. *European Journal of Applied Physiology*, 108, 301-310. 2010.
25. Cramer, J T, Housh, T J, Johnson, G O, Miller, J M, Coburn, J W, and Beck, T W. Acute effects of static stretching on peak torque in women. *Journal of Strength and Conditioning Research*, 18, 236-241. 2004.
26. Cramer, J T, Housh, T J, Weir, J P, Johnson, G O, Coburn, J W, and Beck, T W. The acute effects of static stretching or peak torque, mean power output, electromyography, and mechanomyography. *European Journal of Applied Physiology*, 93, 530-539. 2005.
27. Cramer, J.T, Housh, T J, Coburn, J W, Beck, T W, and Johnson, G O. Acute effects of static stretching on maximal eccentric torque production in women. *Journal of Strength and Conditioning Research*, 20, 354-358. 2006.
28. Cross, K M, and Worrell, T W. Effects of a static stretching program on incidence of lower extremity musculotendinous strains. *Journal of*

Athletic Training, 34, 11-14. 1999.

29. Curry, B S, Chengkalath, D, Crouch, G J, Romance, M, and Manns, P J. Acute effects of dynamic stretching, static stretching, and light aerobic activity on muscular performance in women. *Journal of Strength and Conditioning Research*, 23, 1811-1819. 2009.
30. Dalrymple, K J, Davis, S E, Dwyer, G B, and Moir, G L. Effect of static and dynamic stretching on vertical jump performance in collegiate women volleyball players. *Journal of Strength and Conditioning Research*, 24, 149-155. 2010.
31. Dentiman, G B. Effects of various training programs on running speed. *Research Quarterly*, 35, 456-463. 1964.
32. DePino, G M, Webright, W G, and Arnold, B L. Duration of maintained hamstring flexibility after cessation of an acute static stretching protocol. *Journal of Athletic Training*, 35, 56-59. 2000.
33. Devore, P, and Hagerman, P. A pre-game soccer warm-up. *Strength and Conditioning Journal*, 28, 14-18. 2006.
34. Dixon, P G, Kraemer, W J, Volek, J S, Howard, R L, Gomez, A L, Comstock, B A, Dunn-Lewis, C, Fragala, M S, Hooper, D R, Häkkinen, K, and Maresh, C M. The impact of cold-water immersion on power production in the vertical jump and the benefits of a dynamic exercise warm-up. *Journal of Strength and Conditioning Research*, 24, 3313-3317. 2010.
35. Egan, S. Fitness and health: A holistic approach. Ottawa: *Crimcare*. 1984.
36. Evetovich, T K, Nauman, N J, Conley, D S, and Todd, J B. Effect of static stretching of the biceps brachii on torque, electrmyography, and mechanomyography during concentric isokinetic muscle actions. *Journal of Strength and Conditioning Research*, 17, 484-488. 2003.
37. Evetovich, T K, Cain, R M, Hinnerichs, K R, Engebretsen, B J, and Conley, D S. Interpreting normalized and non-normalized data after acute static stretching in athletes and non-athletes. *Journal of Strength and Conditioning Research*, 24, 1988-1994. 2010.
38. Fletcher, I M, and Jones, B. The effects of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. *Journal of Strength and Conditioning Research*, 18, 885-888. 2004
39. Fletcher, I M, and Monte-Colombo, M M. An investigation into the effects of different warm-up modalities on specific motor skills related to soccer performance. *Journal of Strength and Conditioning Research*, 24, 2096-2101. 2010.
40. Fowles, J R, Sale, D G, and Macdougall, JD. Reduced strength after passive stretch of the human plantarflexors. *Journal of Applied Physiology*, 89, 1179-1188. 2000.
41. Fradkin, A J, Gabble, B J, and Cameron, P A. Does warming up prevent injury in sport? The evidence from randomized controlled trials? *Journal of Science and Medicine in Sport*, 9, 214-220. 2006.
42. Fradkin, A J, Zazryn, T R, and Smoliga, J M. Effects of warming-up on physical performance: a systematic review with meta-analysis. *Journal of Strength and Conditioning Research*, 24, 140-148. 2010.
43. Franco, B L, Signorelli, G R, Trajano, G S, and De Oliveira, C G. Acute effects of different stretching exercises on muscular endurance. *Journal of Strength and Conditioning Research*, 22, 1832-1837. 2008.
44. Frantz, T L, and Ruiz, M D. Effects of dynamic warm-up on lower body explosiveness among collegiate baseball players. *Journal of Strength and Conditioning Research*, 25(11): 2985-2990. 2011.
45. Garcia-Lopez, D, Izquierdo, M, Rodriquez, S, Gonzalez-Culvo, G, Sainz, N, Abadia, O, and Herrero, A J. Interset stretching does not influence the kinematic profile of consecutive bench-press sets. *Journal of Strength and Conditioning Research*, 24, 1361-1368. 2010.
46. Garrison, T T, Nelson, A G, Welsch, M A, and Wood, R M. The effect of acute muscle stretching on maximal voluntary isokinetic torque production in older adults. *Medicine and Science in Sports and Exercise*, 34, S178. 2002.
47. Gelen, E. Acute effects of different wamr-up methods on sprint, slalom dribbling, and penalty kick performance. *Journal of Strength and Conditioning Research*, 24, 950-956. 2010.
48. Gergley, J C. Acute effects of passive static stretching during warm-up on driver clubhead speed, distance, accuracy, and consistent ball contact in young male competitive golfers. *Journal of Strength and Conditioning Research*, 23, 863-876. 2009.
49. Gergley, J C. Latent effect of passive static stretching on driver clubhead speed, distance, accuracy, and consistent ball contact in young male competitive golfers. *Journal of Strength and Conditioning Research*, 24, 3326-3333. 2010.
50. Gergley, J C. Acute effect of passive static stretching on lower-body strength in moderately trained men. *Journal of Strength and Conditioning Research*, 27(4): 973-977. 2013.
51. Gleim, G W, and McHugh, M P. Flexibility and its effects on sports injury and performance. *Sports Medicine*, 24, 289-299. 1997.
52. Godges, J J, MacRae, H, Longdon, C, Tinberg, C, and MacRae, P. The effects of two stretching procedures on hip range of motion and gait economy. *Journal of Orthopaedic and Sports Physical Therapy*, 10, 350-357. 1989.
53. Gomes, T M, Simao, R, Marques, M C, Costa, P B, and Da Silva Novaes, J. Acute effects of two different stretching methods on local muscular endurance performance. *Journal of Strength and Conditioning Research*, 25, 745-752. 2010.
54. Gremion, G. Is stretching for sports performance still useful? A review of the literature. *Revue Medicale Suisse*, 1, 1830-1840. 2005.
55. Guidetti, L, Di Cagno, A, Gallotta, M CC, Battaglia, C, Piazza, M, and Baldari, C. Precompetition warm-up in elite and subelite rhythmic gymnastics. *Journal of Strength and Conditioning Research*, 23, 1877-1882. 2009.
56. Guissard, N, Duchateau, J, and Hainaut, K. Muscle stretching and motor neuron excitability. *European Journal of Applied Physiology and Occupational Physiology*, 58, 47-52. 1988.
57. Gurjao, A L, Goncalves, R, De Moura, R F, and Gobbi, S. Acute effects of static stretching on rate of force development and maximal voluntary contraction in older women. *Journal of Strength and Conditioning Research*, 23, 2149-2154. 2009.
58. Haag, S J, Wright, G A, Gillette, C M, and Greany, J.F. Effects of acute static stretching of the throwing shoulder on pitching performance of national collegiate athletic association division III baseball players. *Journal of Strength and Conditioning Research*, 24, 452-457. 2010.
59. Haddad, M, Dridi, A, Chtara, M, Chaouachi, A, Wong, D P, Behm, D, and Chamari, K. Static stretching can impair explosive performance for at least 24 hours. *Journal of Strength and Conditioning Research*, 28(1): 140-146. 2014.
60. Handrakis, J P, Southard, V N, Abreu, J M, Aloisa, M, Doyen, M R, Echevarria, L M, Hwan, H, Samuels, C, Venegas, S A, and Douris, P C. Static stretching does not impair performance in active middle-aged adults. *Journal of Strength and Conditioning Research*, 24, 825-830. 2010.
61. Hayes, P R, and Walker, A. Pre-exercise stretching does not impact upon running economy. *Journal of Strength and Conditioning Research*, 21, 1227-1232. 2007.
62. Herbert, R D, and Gabriel, M. Effects of stretching before and after exercising on muscle soreness and risk of injury: systematic review. *British Medical Journal*, 325, 468-472. 2002.
63. Herda, T J, Cramer, J T, Ryan, E D, McHugh, M P, and Stout, J R. Acute effects of static versus dynamic stretching on isometric peak torque, electromyography, and mechanomyography. *Journal of Strength and Conditioning Research*, 22, 809-817. 2008.
64. Herman, S L, and Smith, D T. Four-week dynamic stretching warm-up intervention elicits longer-term performance benefits. *Journal of Strength and Conditioning Research*, 22, 1286-1297. 2008.
65. Hough, P A, Ross, E Z, and Howatson, G. Effects of dynamic and static stretching on vertical jump performance and electromyographic activity. *Journal of Strength and Conditioning Research*, 23, 507-512. 2009.
66. Hubley-Kozey, C L, and Starnish, W D. Can stretching prevent athletic injuries? *Journal of Musculoskeletal Medicine*, 7, 21-31. 1990.
67. Hunter, J P, and Marshall, R N. Effects of

power and flexibility training on vertical jump technique. *Medicine and Science in Sports and Exercise*, 34, 478-486. 2002.
68. Jaggers, J R, Swank, A M, Frost, K L, and Lee, C D. The acute effects of dynamic and ballistic stretching on vertical jump height, force, and power. *Journal of Strength and Conditioning Research*, 22, 1844-1849. 2008.
69. Jami, L. Golgi tendon organs in mammalian skeletal muscle: Functional properties and central actions. *Physiological Reviews*, 72, 623-666. 1992.
70. Jeffreys, I. Warm-up and stretching. In T R Baechle, and R W Earle, Essentials of Strength and Training and Conditioning/ National Strength and Conditioning Association (2nd ed., pp. 295-324). Champaign, Il: *Human Kinetics*. 2008.
71. Johansson, P H, Lindstrom, L, Sundelin, G, and Lindstrom, B. The effects of preexercise stretching on muscular soreness, tenderness and force loss following heavy eccentric exercise. *Scandinavian Journal of Medicine and Science in Sports*, 9, 219-225. 1999.
72. Judge, L W, Craig, B, Baudendistal, S, and Bodey, K J. An examination of the stretching practices of division I and division III college football programs in the midwestern United States. *Journal of Strength and Conditioning Research*, 23, 1091-1096. 2009.
73. Keese, F, Farinatti, P, Massaferri, R, Matos-Santos, L, Silva, N, and Monteiro, W. Acute effect of proprioceptive neuromuscular facilitation stretching on the number of repetitions performed during a multiple set resistance exercise protocol. *Journal of Strength and Conditioning Research*, 27(11): 3028-3032. 2013.
74. Kistler, B M, Walsh, M S, Horn, T S, and Cox, R H. 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. *Journal of Strength and Conditioning Research*, 24, 2280-2284. 2010.
75. Knudson, D. Stretching during warm-up: do we have enough evidence? *Journal of Physical Education, Recreation and Dance*, 70, 24-27. 1999.
76. Knudson, D V, Bennett, K, Corn, R, Leick, D, and Smith, C. Acute effects of stretching are not evident in the kinematics of the vertical jump. *Journal of Strength and Conditioning Research*, 15, 98-101. 2001.
77. Knudson, D V, Noffal, G J, Bahamonde, R E, Bauer, J A, and Blackwell, J R. Stretching has no effect on tennis serve performance. *Journal of Strength and Conditioning Research*, 18, 654-656. 2004.
78. Knudson, D, and Noffal, G. Time course of stretch-induced isometric strength deficits. *European Journal of Applied Physiology*, 94, 348-351. 2005.
79. Kokkonen, J, Nelson, A G, and Cornwell, A. Acute muscle stretching inhibits maximal strength performance. *Research Quarterly for Exercise and Sport*, 69, 411-415. 1998.
80. Little, T, and Williams, A G. Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *Journal of Strength and Conditioning Research*, 20, 203-207. 2006.
81. Lopes, F A, Meneyon, E M, Franchini, E, Tricoli, V, and Dem Bertuzzi, R C. Is acute static stretching able to reduce the time to exhaustion at power output corresponding to maximal oxygen uptake? *Journal of Strength and Conditioning Research*, 24, 1650-1656. 2010.
82. Lowery, R P, Joy, J. M, Brown, L E, Oliveira de Souza, E, Wistocki, D R, Davis, G S, Naimo, M A, Zito, G A, and Wilson, J M. Effects of static stretching on 1-mile uphill run performance. *Journal of Strength and Conditioning Research*, 28(1): 161-167. 2014.
83. Manoel, M E, Harris-Love, M O, Danoff, J V, and Miller, T A. Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. *Journal of Strength and Conditioning Research*, 22, 1528-1534. 2008.
84. Marek, S M, Cramer, J T, Fincher, A L, Massey, L L, Dangelmaier, S M, Purkyastha, S, Fitz, K A, and Curlbertson, J Y. Acute effects of static and proprioceptive neuromuscular facilitation stretching elicited acute changes in muscule strength and power output. *Journal of Athletic Training*, 40, 94-103. 2005.
85. Matsuo, S, Suzuki, S, Iwata, M, Banno, Y, Asai, Y, Tsuchida, W, and Inoue, T. Acute effects of different stretching durations on passive torque, mobility, and isometric muscle force. *Journal of Strength and Conditioning Research*, 27(12): 3367-3376. 2013.
86. McBride, J M, Deane, R, and Nimphius, S. Effect of stretching on agonist-antagonist muscle activity and muscle force output during single and multiple joint isometric contractions. *Scandinavian Journal of Medicine and Science in Sports*, 17, 54-60. 2007.
87. McMillan, D J, Moore, JH, Hatler, BS, and Taylor, D C. Dynamic vs. static-stretching warm-up: the effect on power and agility performance. *Journal of Strength and Conditioning Research*, 20, 492-499. 2006.
88. Michael, R, Jerod, G, Steven, B, Bryan, L, and Matt, W. The acute effects of static stretching on leg extension power: quadriceps torque production after a 30-second static stretch versus no stretch. *Proceedings of the 4th Annual GRASP Symposium*. 2008.
89. Mizuno, T, Matsumoto, M, and Umemura, Y. Stretching-induced deficit of maximal isometric torque is restored within 10 minutes. *Journal of Strength and Conditioning Research*, 28(1): 147-153. 2014.
90. Mojock, C D, Kim, J S, Eccles, D W, and Panton, L B. The effects of static stretching on running economy and endurance performance in female distance runners during treadmill running. *Journal of Strength and Conditioning Research*, 25(8): 2170-2176. 2011.
91. Molacek, Z D, Conley, D S, Evetovich, T K, and Himerichs, K R. Effects of low- and high-volume stretching on bench press performance in collegiate football players. *Journal of Strength and Conditioning Research*, 24, 711-716. 2010.
92. Moore, J C. The golgi tendon organ: a review and update. *American Journal of Occupational Therapy*, 38, 227-236. 1984.
93. Muir, I W, Chesworth, B M, and Vandervoort, A A. Effect of a static calf-stretching exercise on the resistive torque during passive ankle dorsiflexion in healthy subjects. *Journal of Orthopaedic and Sports Physical Therapy*, 29, 106-115. 1999.
94. Nelson, A G, and Kokkonen, J. Acute ballistic muscle stretching inhibits maximal strength performance. *Research Quarterly in Exercise and Sport*, 72, 415-419. 2001.
95. Nelson, R T, and Bandy, W D. An update on flexibility. *Strength and Conditioning Journal*, 27, 10-16. 2005.
96. Nelson, AG, Kokkonen, J, and Eldredge, C. Strength inhibition following an acute stretch is not limited to novice stretchers. *Research Quarterly for Exercise and Sport*, 76, 500-506. 2005.
97. Ninos, J. Guidelines for proper stretching. *Strength and Conditioning Journal*, 17, 44-46. 1995.
98. Ogura, Y, Miyahara, Y, Naito, H, Katamoto, S, and Aoki, J. Duration of static stretching influences muscle force production in hamstring muscles. *Journal of Strength and Conditioning Research*, 21, 788-792. 2007.
99. Pacheco, L, Balius, R, Aliste, L, Pujol, M, and Pedret, C. The acute effects of different stretching exercises on jump performance. *Journal of Strength and Conditioning Research*, 25(11): 2991-2998. 2011.
100. Paradisis, G P, Pappas, P T, Theodorou, A S, Zacharogiannis, E G, Skordilis, E K, and Smirniotou, A S. Effects of static and dynamic stretching on sprint and jump performance in boys and girls. *Journal of Strength and Conditioning Research*, 28(1): 154-160. 2014.
101. Perrier, E T, Pavol, M J, and Hoffman, M A. The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility. *Journal of Strength and Conditioning Research*, 25(7): 1925-1931. 2011.
102. Pope, R P, Herbert, R D, and Kirwan, J D. Effects of ankle dorsiflexion range and pre-exercise calf muscle stetching on injury risk army recruits. *Australian Journal of Physiotherapy*,

44, 165-177. 1998.

103. Pope, R P, Herbert, R D, Kirwan, J D, and Graham, B J. A randomized trial of pre-exercise stretching for prevention of lower-limb injury. *Medicine and Science in Sports and Exercise*, 32, 271-277. 2000.

104. Power, K, Behm, D, Cahill, F, Carroll, M, and Young, W. An acute bout of static stretching: effects on force and jumping performance. *Medicine and Science in Sports and Exercise*, 36, 1389-1396. 2004.

105. Reiman, M P, Peitner, A M, Bocher, A L, Cameron, C N, Murphy, J R, and Carter, J W. Effects of dynamic warm-up with and without a weighted vest on lower extremity power performance of high school male athletes. *Journal of Strength and Conditioning Research*, 24, 3387-3395. 2010.

106. Robbins, J W, and Scheuermann, B W. Varying amounts of acute static stretching and its effect on vertical jump performance. *Journal of Strength and Conditioning Research*, 22, 781-786. 2008.

107. Roetert, E P. Stretching the limits of our knowledge on stretching. *Strength and Conditioning Journal*, 26, 58-59. 2004.

108. Rossi, L P, Pereira, R, Simao, R, Brandalize, M, and Gomes, A R. Influence of static stretching duration on quadriceps force development and electromyographic activity. *Human Movement*, 11, 137-143. 2010.

109. Rubini, E C, Costa, A L, and Gomes, P S. The effects of stretching on strength performance. *Sports Medicine*, 37, 213-224. 2007.

110. Safran, M R, Seaber, A V, and Garrett, W E. Warm-up and muscular injury prevention: An update. *Sports Medicine*, 8, 239-249. 1989.

111. Samuel, M N, Holcomb, W R, Guadagnoli, M A, Rubley, M D, and Wallmann, H. Acute effects of static and ballistic stretching on measures of strength and power. *Journal of Strength and Conditioning Research*, 22, 1422-1428. 2008.

112. Sands, W A, McNeal, J R, Stone, M H, Russell, E M, and Jemni, M. Flexibility enhancement with vibration: acute and long-term. *Medicine and Science in Sports and Exercise*, 38, 720-725. 2006.

113. Santana, JC. Flexibility: More is not necessarily better. *Strength and Conditioning Journal*, 26, 14-15. 2004.

114. Schilling, B K, and Stone, M H. Stretching: acute effects on strength and power performance. *Strength and Conditioning Journal*, 22, 44-47. 2000.

115. Shellock, F G, and Prentice, W E. Warming-up and stretching for improved physical performance and prevention of sports-related injuries. *Sports Medicine*, 2, 267-278. 1985.

116. Shrier, I. Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. *Clinical Journal of Sports Medicine*, 9, 221-227. 1999.

117. Shrier, I. Does stretching improve performance? A systematic and critical review of the literature. *Clinical Journal of Sports Medicine*, 14, 267-273. 2004.

118. Siatras, T A, Mittus, V P, Mameletzi, D N, and Vamvakoudis, E A. The duration of the inhibitory effects with static stretching on quadriceps peak torque production. *Journal of Strength and Conditioning Research*, 22, 40-46. 2008.

119. Siff, M C. Supertraining: Strength Training for Sporting Excellence. Denver: *Supertraining International*. 2000.

120. Sim, A Y, Dawson, BT, Guelfi, K J, Wallmann, K E, and Young, W B. Effects of static stretching in warm-up on repeated sprint performance. *Journal of Strength and Conditioning Research*, 23, 2155-2162. 2009.

121. Simonson, E, Teslenko, N, and Gorkin, M. Influence of warm-up on 100m run time. *Journal of Physiology*, 9, 152. 1936.

122. Smith, C. The warm up procedure: To stretch or not to stretch. A brief review. *Journal of Orthopaedic and Sports Physical Therapy*, 27, 12-17. 1994.

123. Spernoga, S G, Uhl, T, Arnold, B L, and Gansneder, B M. Duration of maintained hamstring flexibility after a one-time, modified hold-relax stretching protocol. *Journal of Athletic Training*, 36, 44-48. 2001.

124. Stone, M, O'Bryant, H S, Ayers, C, and Sands, W A. Stretching: Acute and chronic? The potential consequences. *Strength and Conditioning Journal*, 28, 66-74. 2006.

125. Swanson, J. R. A functional approach to warm-up and flexibility. *Strength and Conditioning Journal*, 28, 30-36. 2006.

126. Taylor, J M, Weston, M, and Portas, M D. The effect of a short practical warm-up protocol on repeated sprint performance. *Journal of Strength and Conditioning Research*, 27(7): 2034-2038. 2013.

127. Thomas, M. The functional warm-up. *Strength and Conditioning Journal*, 22, 51-53. 2000.

128. Torre, A L, Custagna, C, Gervasoni, E, Ce, E, Rampichini, S, Ferrarin, M, and Merati, G. Acute effects of static stretching on squat jump performance at different knee starting angles. *Journal of Strength and Conditioning Research*, 24, 687-694. 2010.

129. Torres, E M, Kraemer, W J, Vingren, J L, Vollek, J S, Hatfield, D L, Spiering, B A, Ho, J Y, Fragala, M S, Thomas, G A, Anderson, J M, Häkkinen, K, and Maresh, C M. Effects of stretching on upper-body muscular performance. *Journal of Strength and Conditioning Research*, 22, 1279-1285. 2008.

130. Unick, J, Kieffer, H S, Cheesman, W, and Feeney, A. The acute effects of static and ballistic stretching on vertical jump performance in trained women. *Journal of Strength and Conditioning Research*, 19, 206-212. 2005.

131. Van Gelder, L H, and Bartz, S D. The effect of acute stretching on agility performance. *Journal of Strength and Conditioning Research*, 25(11): 3014-3021. 2011.

132. Wallmann, H W, Mercer, J A, and McWhorter, J W. Surface electromyographic assessment of the effect of static stretching of the gastrocnemius on vertical jump performance. *Journal of Strength and Conditioning Research*, 19, 684-688. 2005.

133. Weir, D E, Tingley, J, and Elder, G C. Acute passive stretching alters the mechanical properties of human plantar flexors and the optimal angle for maximal voluntary contraction. *European Journal of Applied Physiology*, 93, 614-623. 2005.

134. Wilmore, J H, and Costill, D L. Physiology of sport and exercise. Leeds: *Human Kinetics*. 2004.

135. Wilson, J M, Hornbuckle, L M, Kim, J.-S, Ugrinowitsch, C, Lee, S-R, Zoudros, M. C., Sommer, B., and Panton, L. B. Effects of static stretching on energy cost and running endurance performance. *Journal of Strength and Conditioning Research*, 24, 2274-2279. 2010.

136. Wolfe, A. E, Brown, L E, Coburn, J. W., Kersey, R. D., and Bottaro, M. Time course of the effects of static stretching on cycling economy. *Journal of Strength and Conditioning Research*, 25(11): 2980-2984. 2011.

137. Wong, P. L., Lau, P. W., Mao de, W., Wu, Y. Y., Behm, D. G., and Wisløff, U. Three days of static stretching within a warm-up does not affect repeated-sprint ability in youth soccer players. *Journal of Strength and Conditioning Research*, 25(3): 838-845. 2011.

138. Woods, K, Bishop, P, and Jones, E. Warm-up and stretching in the prevention of muscular injury. *Sports Medicine*, 37, 1089-1099. 2007.

139. Woolstenhulme, M T, Griffiths, C M, Woolstenhulme, E M, and Parcell, A C. Ballistic stretching increases flexibility and acute vertical jump height when combined with basketball activity. *Journal of Strength and Conditioning Research*, 20, 799-803. 2006.

140. Yamaguchi, T, and Ishii, K. Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. *Journal of Strength and Conditioning Research*, 19, 677-683. 2005.

141. Young, W B, and Behm, D G. Should static stretching be used during a warm-up for strength and power activities? *Strength and Conditioning Journal*, 24, 33-37. 2002.

142. Zakas, A, Doganis, G, Galazoulas, C, and Vamuakoudis, E. A. Effect of acute static stretching duration on isokinetic peak torque in pubescent soccer players. *Pediatric Exercise Science*, 18, 252-261. 2006.