Warm up revisited – the 'ramp' method of optimising performance preparation

Ian Jeffreys BA(Hons), MSc, CSCS*D, ASCC, NSCA-CPT*D

Ian Jeffreys is currently Director of Athletics and Athletic Performance at Coleg Powys in Brecon, Wales. He is the Strength and Conditioning Coach for the Welsh Schools Rugby Union National team at Under 16 level.

A registered Strength and Conditioning Coach with the British Olympic Association, an NSCA Coach Practitioner, and a Board Member of the United Kingdom Strength and Conditioning Association, Ian was voted the NSCA High School Professional of the Year in 2006.

While some elements of the strength and conditioning portfolio have yet to achieve acceptance in the preparation of athletes in all sports, one area of practice which is almost universally accepted is the principle of the warm-up. Today, few athletes at any level train or compete without some attempt at a "warm-up". However, while the general principles surrounding the need to warm-up remain valid, a large body of evidence is building up which both questions some of our current practices, and provides possible opportunities to improve practice. This article looks at current practice, and presents a model around which to construct effective warm-ups.

Why do we warm-up?

An important starting point in examining optimal application of warm-up is to examine the rationale behind why we warm-up. In its simplest terms, the goal of the warm-up is to prepare the athlete mentally and physically for exercise or competition.[21] A well designed warm-up can increase muscle temperature, core temperature, blood flow[26] and also disrupt transient connective tissue bonds.[13] These effects can have the following positive effects on performance:

- Faster muscle contraction and relaxation of both agonist and antagonist muscles.[21]
- Improvements in rate of force development and reaction time.[1]
- Improvements in muscle strength and power.[5,13]
- Lowered viscous resistance in muscles.[13]
- Improved oxygen delivery due to the Bohr effect where higher temperatures facilitate oxygen release from haemoglobin and myoglobin.[26]
- Increased blood flow to active muscles.[26]
- Enhanced metabolic reactions.[13]

Additionally, a common reason given by coaches for a warm-up is a reduction in the risk of injury. Whilst the influence of a warm-up on injury prevention is unclear, the evidence suggests a positive effect.[17,34]

A well designed warm-up can clearly have a positive effect on subsequent performance, and a useful way of looking at warm-up is as "performance preparation", enabling an athlete to perform maximally in their workout/competition. With this performance preparation approach, the methods used in warm-up can be selected and evaluated to provide optimal effect on performance.

A coaching opportunity

One of the challenges facing a strength and conditioning coach is limited time, and the need to include a range of training stimuli to the athlete. A well planned warm-up can provide an ideal opportunity to include a range of stimuli in the training programme, without creating an additional work load on the athlete. Ideally, a warm-up should be an integral part of the training session, providing for optimal performance preparation but also contributing to the overall

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training effect. To this end, planning of the warm-up is as important as planning the main session itself. By carefully selecting activities, the warm-up can contribute greatly to the overall training programme, and should be in balance with the aim of the session, and the aim of the programme. To facilitate this, activities can be chosen which contribute to the aims of the overall session, and contribute to the aims of the given training cycle. In this way, a well planned warm-up is an extremely time effective method of including a number of key elements within a training programme, elements which may not be able to be included if they have to entail their own specific time frame. Most warm-ups will last from 10-30 minutes. Over a training cycle, that contributes a massive amount of training time, which, with effective planning, can be used to work productively on a range of areas, without increasing the overall training load.

Traditional components of a warm-up

If the aim of a warm-up is to prepare for competition or practice, the the optimal warm-up is likely to vary between sports, and warm-ups need to be constructed that address the specific needs of both the athlete and sport. These need to take into account the physiological and biomechanical requirements of the sport, as well as the technical requirements of the sport itself. While warm-up has traditionally focussed on energy system and muscular aspects of the physiological processes, the neurological aspects of warm-up have often been overlooked. For optimal effectiveness, a warm-up needs to provide optimum preparation in all aspects of performance. Indeed Gambetta[19] argues that the stimulation of the nervous system is the most important part of the warm-up.

However, despite this need for specificity, a number of key phases have traditionally been identified, a general warm-up and a specific warm-up.[22]. The general phase has been associated with increases in heart rate, respiration rate, blood flow, and joint fluid viscosity,[12] and normally consists of light activities such as jogging. The specific phase has traditionally consisted of stretching and sport specific movements.[22]

The use of stretching

Perhaps the greatest debate regarding warm-up at present is the use of static stretching. Static stretching has become an integral part of many warm-up routines, with injury prevention and performance enhancement being given as justifications for its inclusion. However, there is little, if any, evidence that stretching pre or post participation prevents injury.[20,29,33,34,37] Similarly, in terms of the performance enhancement elements, research suggests that rather than enhance subsequent performance, static stretching can compromise muscle performance.[23]

In terms of performance decrements after static stretching, research has indicated potential decrements in force production,[3,9,10,11,14,30] power performance,[8,40,43] running speed,[16] reaction time,[4] and strength endurance.[28] PNF[7] (Proprioceptive Neuromuscular Facilitation) and ballistic stretching[27] have also been shown to have detrimental effects of performance. While some studies have found that static stretching has no effect on subsequent performance,[25,38,41] there is sufficient evidence to question the use of static stretching in warm-up, and the justification to look at other methods which do not have the potential to reduce performance, and which may offer more functional methods of enhancing performance.

Dynamic stretching on the other hand does not seem to cause the performance reduction effects of static and PNF stretching[16] and has been shown to improve subsequent running performance.[16,25,41] Additionally, the dynamic nature of dynamic stretching is more functional than static stretching given the need for active and dynamic methods to be used in functional warm-ups.[19] Effective dynamic stretches also require that the muscle is activated through the range of movement, which contributes to the neural activation requirements of effective warm-ups. Given this, dynamic stretching may be the most suitable method of mobilization during warm-up for a number of sports. It is important to note however, that static stretching before activity might increase performance in sports that require an increased range of motion, such as gymnastics.[37]

Towards a new classification of warm-up

Given the opportunity to use warm-ups as part of the training process and the evidence questioning many current practices in warm-up, it may be prudent to develop a new classification of warm-up phases. This would help remove some of the key "grey areas" of current practice, and also provide a framework around which to build effective warm-ups. In this way the effectiveness of warm-up practices can be evaluated in terms of its effect on performance and its effectiveness as part of the training process. This would be similar to the approach taken by Verstegen[39] who has re-termed warm-up as movement preparation, which reflects the approach he takes to effective warm-up.

To this end the following "RAMP" system may provide a method by which warm-up activities can be classified and constructed. This system identifies three key phases of effective warm-ups.

1. Raise
2. Activate and Mobilise
3. Potentiate

Raise

This phase has the aim of elevating body temperature, heart rate, respiration rate, blood flow and joint fluid viscosity via low intensity activities. Whilst this is common practice, the methods used to achieve it often represents perhaps the biggest waste of valuable training time in many programmes, with the common jog around a field still a common sight. Given the limited training time a strength and conditioning coach has with the athletes, and the contribution that warm-up can play in the training process, this phase can be dedicated to movement skills and/or sport skills. Over a training year these activities can contribute a massive amount of time dedicated to developing these key elements. By identifying elements such as key movement patterns or techniques involved in a sport, the strength and conditioning professional can construct routines that develop and hone these effectively whilst still providing for the elevation elements needed within the warm-up.

Activate and mobilize

This phase has two key aims

1. To activate key muscle groups.
2. To mobilize key joints and ranges of motion used in the sport.

In terms of specific activation, the inclusion of this will depend upon the needs of the athlete and/or the sport. In some instances, where key muscle groups may need to be stimulated, exercises can be selected that target these key muscles. This can often involve exercises traditionally associated with prehab such as mini band routines, rotator cuff exercises, glute bridges, overhead squats etc. This is a time efficient method of including these exercises in the training programme, and the extent of this phase will depend upon the individual sport and the individual athlete's needs.

The achievement of the mobilization phase of the warm-up takes a radically different approach than the traditional static stretching approach. Rather than focus on individual muscles, the approach is to work on movements. This has a number of key advantages. First, the dynamic nature contributes to maintaining the elevation effects of the first period. Secondly the movements are more specific to those found in the sport, and thirdly it is extremely time efficient. Additionally, it has a physiologically different approach. Whilst static stretching involves a relaxation of the muscle, the activation and mobilization approach involves actively working a muscle through its range of motion, which has the effect of activating all of the key muscles involved both directly in the movements and also in the stabilsation of the body through the movements. In this way preparation for activity is enhanced, as muscles are activated, as well as mobilized through key movements.

In designing the activate and mobilization phase, the strength and conditioning professional needs to identify the key movement patterns involved in the sport, together with key muscles that need to be activated in order to produce these movements. A series of dynamic stretches can then be selected which provide for the activation and mobilization needed for effective sports performance. This type of approach helps maintain the beneficial effects of the elevation section of the warm-up, and can also be extremely time efficient, as by focusing on movements, many muscle groups can be activated and mobilized with the same movement, rather than with the single muscle approach of traditional static stretching routines.

Coaches should be encouraged to develop a range of dynamic movements that can activate key areas and which contribute to the overall session aims. In this way, they can bring variety to the warm-up routines, and also provide for the variability which can contribute to training gains.

Potentiation

The term 'potentiation' refers to activities that improve effectiveness, and in the case of the warm-up involves the selection of activities that will improve the effectiveness of subsequent performance. This phase of the warm-up will see a gradual shift towards the actual sport performance or workout itself, and will normally involve sport specific activities of increasing intensity. Including these high intensity dynamic exercises can facilitate subsequent performance,[6,15,42] and is the essence of the potentiation phase of the warm-up. The nature of the activities will depend upon the specific nature of the activities to perform, e.g. a sprint workout will comprise of sprint drills and sprints of increasing intensity. Additionally, they may also comprise of activities that increase elements of physical performance that may contribute to higher levels of subsequent performance.

The potentiation phase of the warm-up can have two aims.

1. The first, and most common aim, is to increase the intensity of exercise to a point at which athletes are able to perform their training/match activities at their maximal levels.
2. The second, and least common application, is to select activities that may contribute to a super-maximal effect, where the activities chosen contribute to an enhanced performance effect, via the utlilisation of the post-activation potentiation (PAP) effect.

For the former aim, what is important is that a series of activities are engaged in that allow the athlete to achieve their peak performance when the workout or competition begins. For running workouts, speed and agility drills are ideal at this time, in that they provide for a progressive potentiation effect, which at the same time provides a very real training benefit. The performance of speed/agility drills in this section of the warm-up can be a very time efficient way of ensuring athletes receive regular doses of progressive speed and agility training, at the optimal time in any workout. Using speed and agility type drills at this time ensures that the athlete undertakes these when they are fresh, and when the training will result in the greatest benefits.

For resistance training workouts, plyometric, medicine ball, and lighter or explosive resistance exercises can be used which provide a progression towards the workout itself, and which provide a stimulus to allow maximal effort on the first sets.

In terms of the PAP effects, the application of post-activation potentiation research may provide an avenue by which to enhance the overall effectiveness of the warm-up, especially in sports requiring high force and power outputs. Force and power production is dependent upon both the muscles and tendons capacity, and the ability of the neural system to activate the muscles. As Gandevia[18] asserts, "muscles are the servants of the brain". In studying the force output of a muscle, it is important to note that motor units are capable of firing at different frequencies, and that the activation depends upon the level of excitation of the motoneurones by the CNS.[31] Thus there are subtle changes that take place in the neural control of sports based movements, and in the muscle tendon characteristics during different activities. What is important is to determine whether these can be influenced by potentiating exercise. In this way PAP type activities could have a beneficial effect on subsequent performance.

However, post-activation potentiation in human performance is a relatively new field of study, and thus definitive conclusions as to its effectiveness, and the most efficacious methods of eliciting performance enhancement through PAP is very limited.[32] Hopefully, further research into this area will highlight areas which can optimize the potentiation of performance through the use of PAP type activities.

Conclusions

The "RAMP" approach provides a framework around which to construct effective warm-up procedures for both competition and the workout. At all times the aim of the warm-up must always be kept in mind, that is to ensure optimal preparation for performance, and activities should be selected that provide for raising, activation, mobilisation and potentiation, but without the development of undue fatigue.

Additionally, effective planning of warm-up periods through the training week can provide for ergonomically effective workouts. Effective movement/skill based elevation sections allow for a great deal of skill or movement development activity, but with no additional time load on the athlete. Similarly, effective activation & mobilization activities allow for the effective deployment of mobility and prehab training, with again no additional time requirement.

The potentiation sector also provides an ideal time to carry out activities such as speed and agility work, and again can provide a very time efficient method by which to ensure athletes have controlled doses of this type of training throughout the training year. Additionally, as research on the effects of PAP becomes available, this may provide a framework around which to maximize this effect for specific sports.

References

1. Asmussen E, Bonde-Peterson F and Jorgenson K. Mechano-elastic properties of human muscles at different temperatures. Acta Physiologica Scandinavica. 96:86–93 1976.
2. Baechle, T.R and Earle, R.W. Essentials of Strength Training and Conditioning (Second Edition). Champaign Ill: Human Kinetics 2000.
3. Behm DG, Button DC, Butt JC.Factors affecting force loss with prolonged stretching.Can J Appl Physiol. Jun;26(3):261–72 2001.
4. Behm DG, Bambury A, Cahill F, Power K. Effect of acute static stretching on force, balance, reaction time, and movement time. Med Sci Sports Exerc. Aug; 36(8):1397–402 2004.
5. Bergh U and Ekblom B Influence of muscle temperature on maximal strength and power output in human muscle. Acta Physiologica Scandinavica 107:332–337 1979.
6. Burkett LN, Phillips WT, Ziuraitis J. The best warm-up for the vertical jump in college-age athletic men. J Strength Cond Res. Aug;19(3):673–6 2005.
7. Church JB, Wiggins MS, Moode FM, Crist R. Effect of warm-up and flexibility treatments on vertical jump performance.J Strength Cond Res. Aug;15(3):332–6 2001.
8. Cornwell A, Nelson AG, Sidaway B. Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. Eur J Appl Physiol. 2002 Mar;86(5):428–34 2002.
9. Cramer JT, Housh TJ, Johnson GO, Miller JM, Coburn JW, Beck TW. Acute effects of static stretching on peak torque in women. J Strength Cond Res. May;18(2):236–41 2004
10. Cramer JT, Housh TJ, Weir JP, Johnson GO, Coburn JW, Beck TW. The acute effects of static stretching on peak torque, mean power output, electromyography, and mechanomyography. Eur J Appl Physiol. Mar;93(5-6):530–9 2005.
11. Cramer JT, Housh TJ, Coburn JW, Beck TW, Johnson GO.Acute effects of static stretching on maximal eccentric torque production in women. J Strength Cond Res. May;20(2):354–8 2006.
12. deVries, H.A. Physiology of Exercise for Physical Education and Athletics. Dubuque, IA: Brown 1974.
13. Enoka, RM. Neuromechanics of Human Movement. Champaign Ill: Human Kinetics 2002.
14. Evetovich TK, Nauman NJ, Conley DS, Todd JB. Effect of static stretching of the biceps brachii on torque, electromyography, and mechanomyography during concentric isokinetic muscle actions. J Strength Cond Res. Aug;17(3):484–8 2003.
15. Faigenbaum AD, Bellucci M, Bernieri A, Bakker B, Hoorens K. Acute effects of different warm-up protocols on fitness performance in children. J Strength Cond Res. May;19(2):376–81 2005.
16. Fletcher IM, Jones B. The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. J Strength Cond Res. Nov;18(4):885–8 2004.
17. Fradkin AJ, Gabbe BJ, Cameron PA. Does warming up prevent injury in sport? The evidence from randomised controlled trials? J Sci Med Sport. Jun;9(3):214–20 2006.
18. Gandevia, S.C. Mind muscles and motoneurones. Journal of Science and Medicine in Sport. 2(3), 167–180 1999.
19. Gambetta, V, Athletic Development – The Art and Science of Functional Sports Conditioning. Champaign Ill: Human Kinetics 2007.
20. Herbert RD and Gabriel M. Effects of stretching before and after exercise on muscle soreness and risk of injury: a systematic review. Br Med J: 325: 468–470 2002.
21. Hoffman J Physiological Aspects of Sports Performance and Training. Champaign Ill: Human Kinetics 2002
22. Holcomb, W.R Stretching and Warm Up. In Baechle and Earle 2000.
23. Knudson DV, Magnusson P and McHugh M. Current issues in flexibility fitness. Pres Council Phys fitness Sports 3:1–6 2000.
24. Komi, P.V. Strength and Power in Sports : Cambridge MA: Blackwell 1992.
25. Little T, Williams AG. Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. .J Strength Cond Res. Feb;20(1):203–7 2006.
26. McArdle WD, Katch Fi and Katch VL. Exercise Physiology: Energy, Nutrition and Human Performance (Fifth Ed) Baltimore: Lippincott Williams ansd Wilkins 2001.
27. Nelson AG, Kokkonen J. Acute muscle stretching inhibits maximal strength performance. Res Q Exerc Sport. Dec; 72(4): 415–419 2001.
28. Nelson AG, Kokkonen J, Arnall DA. Acute muscle stretching inhibits muscle strength endurance performance. J Strength Cond Res. May;19(2):338–43 2005.
29. Pope RP, Herbert RD, Kirwan JD et al. A randomised trial of pre-exercise stretching for prevention of lower limb injury. Med Sci Sports Exerc. 32: 271–277 2000.
30. Power K, Behm D, Cahill F, Carroll M, Young W. An acute bout of static stretching: effects on force and jumping performance.Med Sci Sports Exerc. Aug;36(8):1389–96 2004.
31. Sale, D.G. (1992), Neural adaptations to strength training. In Komi P.(1992) pp249–265.
32. Sale, D.G Postactivation potentiation: Role in human performance. Exercise and Sport Science Reviews 30(3). 138–143 2002.
33. Shrier I. Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. Clin J Sport Med. Oct;9(4):221–7 1999.
34. Shrier I. Stretching before exercise: an evidence based approach. Br J Sports Med. Oct;34(5):324–5 2000.
35. Shrier I. Does stretching improve performance? A systematic and critical review of the literature. Clin J Sport Med. Sep;14(5):267–73 Review 2004.
36. Shrier I Meta-analysis on pre-exercise stretching. Med Sci Sports Exerc. Oct;36(10):1832 2004.
37. Thacker SB, Gilchrist J, Stroup DF, Kimsey CD Jr.The impact of stretching on sports injury risk: a systematic review of the literature. Med Sci Sports Exerc. Mar;36(3):371–8 2004.
38. Unick J, Kieffer HS, Cheesman W, Feeney A. The acute effects of static and ballistic stretching on vertical jump performance in trained women. J Strength Cond Res. Feb;19(1):206–12 2005.
39. Verstegen, M and Williams P. Core performance. Rodahl: New York 2004.
40. Wallmann HW, Mercer JA, McWhorter JW. Surface electromyographic assessment of the effect of static stretching of the gastrocnemius on vertical jump performance. J Strength Cond Res. Aug;19(3):684–8 2005.
41. Yamaguchi T, Ishii K. Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. J Strength Cond Res. Aug;19(3):677–83 2005.
42. Young WB, Behm DG. Should static stretching be used during a warm up for strength and power activities. Strength and Conditioning Journal. 24(6):33-37 2002.
43. Young WB, Behm DG. Effects of running, static stretching and practice jumps on explosive force production and jumping performance. J Sports Med Phys Fitness. Mar;43(1):21-7 2003.