ACUTE EFFECTS OF PRE-EXERCISE FOAM ROLLING IN ADDITION TO DYNAMIC STRETCHING ON ANAEROBIC POWER[1]

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ABSTRACT

Recently, self-myofascial release with foam roller has become an increasingly popular method and commonly used both before and after a workout. However, there are limited studies demonstrating the efficacy of foam rolling on anaerobic power. The aim of the current study was to determine the acute effects of pre-exercise foam roller intervention in addition to dynamic stretching on anaerobic power. Twenty-one healthy collegian students [13 men (age: 20.43±1.53 years, height: 176.84±8.23 cm, weight:: 74.89±15.72 kg) and 8 women (age: 21.32±1.62 years, height: 170.79±9.02 cm, weight: 67.98±13.62 kg)] were volunteered to participate in the current study. The participants performed a dynamic stretching or the foam rolling intervention in addition to dynamic stretching and then performed anaerobic power test (Wingate) with two days interval. The paired t-test was used to compare two protocols. Peak power (respectively, 889,50±232,80 vs 793,71±224,84 Watt, p<0.01, respectively) and average power (608,11±132,46 vs 578,56±120,35 Watt, p<0.05, respectively) were significantly greater after foam rolling intervention in addition to dynamic stretching when compared with dynamic stretching in the male group. However, there were not significant differences in the female group. As a conclusion, it was seen that as a warm-up pre-exercises foam roller intervention in addition to dynamic stretching was more effective on anaerobic power than dynamic stretching without a foam roller in the male group.

Keywords: Foam rolling, Self-myofascial, Anaerobic power, Dynamic stretching

ANTRENMAN ÖNCESİ DİNAMİK ISINMAYA EK OLARAK YAPILAN FOAM ROLLER UYGULAMASININ AKUT GÜÇ ÇIKIŞI ÜZERİNE ETKİLERİ

ÖZET

Son yıllarda foam roller cihazı ile yapılan self-miyofasyal gevşetme yöntemi antrenmandan önce ve sonra yaygın olarak kullanılmaya başlanmıştır. Fakat foam roller ile yapılan self-miyofasyal gevşetme yönteminin anaerobik güç üzerine olan etkilerini gösteren sınırlı sayıda çalışma bulunmaktadır. Bu çalışmanın amacı antrenman öncesi dinamik ısınmalara ek olarak yapılan foam roller uygulamalarının anaerobik güç üzerine akut etkilerinin belirlenmesidir. Çalışmaya yirmi bir üniversite öğrencisi [13 erkek (Yaş: 20.43±1,53 yıl, boy: 176.84±8.23 cm, kilo: 74.89±15.72 kg) ve 8 kadın (yaş: 21.32±1.62 yıl, boy: 170.79±9.02 cm, kilo: 67.98±13.62 kg)] gönüllü olarak katılmıştır. Katılımcılar iki gün arayla önce dinamik ısınma sonra dinamik ısınmaya ek olarak foam roller uygulaması ve uygulamalardan sonra anaerobik güç (Wingate bisiklet testi) testini gerçekleştirmişlerdir. Uygulatılan protokoller sonrası anaerobik güç değerlerinin istatistiksel olarak karşılaştırılmasında paired t-test kullanılmıştır. Dinamik ısınmaya ek olarak self-miyofasyal gevşetme yöntemi uygulatılmış erkek gruptaki zirve güç (sırasıyla 889,50±232,80 karşın 793,71±224,84 Watt, p<0.01) ve ortalama güç (608,11±132,46 karşın 578,56±120,35 Watt, p<0.05) değerleri sadece dinamik ısınma yapmış gruptan anlamlı derecede fazla bulunmuştur. Kadın katılımcılar üzerinde herhangi bir anlamlı fark tespit edilmemiştir. Sonuç olarak egzersiz öncesi dinamik ısınmaya ek olarak self-mİyofasyal gevşetme yöntemi uygulayan katılımcıların, sadece dinamik ısınma uygulamış katılımcılara göre güç parametrelerinin anlamlı derecede daha yüksek olduğu tespit edilmiştir.

Anahtar Kelimeler: Foam roller, Miyofasya, Anaerobik güç, Dinamik streçhing

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INTRODUCTION

An aim of a pre-exercise warm-up event is to maximize athletic performance. Warm-ups are generally including a low intensity aerobic activity (ie. running, cycling), stretching type (static, dynamic or mix), and sport-specific activities[10]. The goal of the low intensity aerobic exercise is to increase the body temperature 1–2^{0}C[39,40]. The increased temperature in muscle and body increases enzymatic cycling, muscle compliance, and nerve conduction velocity[11,39]. Traditionally, static stretching workouts are used as a second component after submaximal aerobic activity[39,40], and they usually include extending an extremity to the end of its range of motion (ROM) and keeping this position for 15–60-sec[33,40]. It has been suggested that static stretching can be used as an effective method to increase ROM[3,39]. However, there are many studies demonstrating negative effect of static stretching on muscular performance[6,7,8,9,22]. In contrast to static stretching, it has been determined that dynamic stretching significantly improves anaerobic performance such as, short sprint, vertical jump, and agility because of elevated ‘‘core’’ body temperature[30] and enhanced motor unit excitability[20]. Therefore, it has been suggested that a dynamic warm-up including dynamic stretching should be used as a method to improve athletic performance[10].

In the recent years, self-myofascial release (SMR) has become an increasingly popular method to support classical interventions in strength and conditioning fields and commercial gyms[13,14,16]. This current method has been used by a foam roller (FR). The targeted musculature is rolled and compressed with the FR device[18,24,37] in which individuals use their own body mass on the device to exert pressure on the affected soft tissues known as fascia by varying body position. These muscles groups mostly include the hip adductors, gluteal muscles, hamstrings, quadriceps, calf muscles, and trapezius[10] and they are surrounded by the fascia which influence flexibility and joint range of movement. It is well known that using a foam roller makes the fascia more flexible and breaks down scar tissue and adhesions [38].

While SMR has been generally seen as a post-exercise therapeutic technique for recovery and repair (e.g., soft tissue restoration and vascular plasticity)[1,2,29,34] more recently, it has been began to use by the sports and exercise researches as a pre-exercise technique to enhance athletic performance[32,37]. It has been demonstrated that similar to dynamic stretching self-myofascial release with FR helps to reform muscle length–tension relationships and allow for better warm-up[12,16]. The reason for this is that FR leads to a rise of nitric oxide, myogenic and endothelial dilation[34]. Therefore, pre-exercise FR intervention may improve performance because of myofascial release by leading to increased neuromuscular efficiency and mobility[14,16].

Consequently, many trainers and coaches use myofascial release with FR as a pre-exercise warm-up technique to improve athletic performance[35]. There are a lot of studies using FR intervention as a pre-exercise warm-up technique just alone when they compared with series of planking exercise[24], dynamic stretching[5, 28], static stretching[19, 23], and control group[33]. However, there has not been enough information to evaluate pre-exercise the FR intervention in addition to a dynamic stretching on anaerobic power. Therefore, we hypothesized that the FR intervention in addition to the dynamic stretching may be more effective on anaerobic power when compared with dynamic stretching without the FR. The purpose of the current study was to determine the effects of the pre-exercise FR intervention in addition to dynamic stretching on anaerobic power.

METHODS

Experimental Approach to the Problem

All participants completed one day of familiarization and two days of experimental trials. First experimental trial included of a dynamic stretching (DYN) session followed by an anaerobic power test. On the other experimental trial, the participants performed dynamic stretching in addition to the FR intervention (Trigger point, USA) followed by the anaerobic power test. The aim was to determine the effects of foam rolling addition to DYN stretching on a anaerobic power compared with the control condition of dynamic stretching without FR intervention.

Participants

Twenty-one healthy collegian students thirteen males (age: 20.43±1.53 years, height: 176.84±8.23 cm, weight: 74.89±15.72 kg) and eight females (age: 21.32±1.62 years, height: 170.79±9.02 cm, weight: 67.98±13.62 kg) volunteered to participants in this study. The all participants were recreationally active (participating in regular physical activity at least 2–3 times per week/ 1-2 hour a day). The written information was obtained from each participant. The study was approved by the ethics committee of the Afyon Kocatepe University with approved number 230 at the beginning of the study.

Procedures

Participants' physical characteristics including body weight and height were assessed using a stadiometer during the familiarization session. Following the familiarization session and physical characteristics testing, subjects participated in two separate experimental sessions (DYN, DYN+FR). Sessions were separated by three days. Two minutes later after completing one of the sessions, participants performed anaerobic power test. Each of the sessions carried out at the same place and the same time of day. All participants were asked to refrain from physical activity and to follow similar diet program during two days before intervention session to minimize the effect of increase caffeine intake carbohydrate. Same external encouragement and information was provided to approach for maximal anaerobic power test for all subjects in two sessions testing.

Stretching trials

DYN trial included of a 5-min low intensity jogging at self-selected pace and a 10-min of dynamic stretching. Dynamic stretching consisted of the lower-limb muscle groups (hip flexors, gluteals, adductors, quadriceps, hamstrings and gastrocnemius). The intensity of the movements progressed from moderate to high intensity. The dynamic stretching was performed for a duration of 30-sec with a 10-sec recovery period between each exercise and was repeated two times on each leg. Each technique was performed bi-laterally with no rest period when changing the limb. The dynamic stretching exercises used were described by Chaouach et al., (2010).

DYN+FR session also consisted of a 5-minute low intensity jogging at self-selected pace, a 5-min (once on each leg) dynamic stretching (described above) and 5-min a variety of foam roller techniques (Trigger point, USA). Similar to dynamic stretching, the rolling process targeted the lower-extremity muscle groups which included gluteal region, the hamstring region, and finally the calf region from the supine body position. The same process followed with the quadriceps/flexor region from the prone body position. The participants used their body mass by rolling on the device to exert pressure on each group of muscles. The process was conducted at per 30-sec with 10-sec of rest between muscle groups. Each technique was performed bi-laterally with no rest period when changing the limb.

Figure 1: application of foam roller

Anaerobic power measurement

The participants performed anaerobic power test (Wingate) after two different pre-exercise sessions: DYN and DYN+FR. Participants' anaerobic power was assessed with a 30-sec Wingate test using the Monark 894E Peak Bike (Varburg, Sweden). The variables measured in anaerobic power included average power output (APO) and peak power output (PPO). During the measurements, the participants were encouraged to reach the best results.

Statistical Analysis

Statistical analysis was carried out on SPSS 18.0 (Statistical Package for Social Sciences, Chicago, IL, USA). All data were expressed as mean and standard deviation (Sd). Normality of the distribution and homogeneity of variance were calculated with the Kolmogorov Smirnov test and Levene test, respectively. A paired t-test was used for the comparison of the peak power and average power results of participants after DYN and DYN+FR. An a priori alpha level of 0.05 was used to determine statistical significance.

Results

Table 1 outlines that peak power (793,71±224,84 vs 889,50±232,80 Watt, $p<0.001$) and average power (578,56±120,35 vs 608,11±132,46 Watt, $p<0.05$) are significantly greater after FR intervention in addition to dynamic stretching when compared with dynamic stretching without the foam roller in the male group. However, there are no significant differences between foam rolling intervention in addition to dynamic stretching and dynamic stretching without the foam roller in the female group.

Table 2 presents very high intraclass correlation coefficient values for peak power and average power in male (respectively, 0.976 and 0.979, $p<0.05$) and female participants (respectively, 0.931and 0.903, $p<0.05$).

Table 1. Results of participants for anaerobic power tests

Variables	Male (n:13)		Female (n:8)	
	DYN	DYN+FR	DYN	DYN+FR
PP (Watt)	793,71±224,84	889,50±232,80**	437,31±93,74	477,21±151,09
AP (Watt)	578,56±120,35	608,11±132,46*	298,28±52,42	317,10±66,81

*p<0,05; **p<0,01, PP: Peak Power, AP: Average Power

Table 2. İntraclass correlation coefficient of two warm-up protocols

Variables	Male (n:13)	Female (n:8)
	DYN/DYN+FR	DYN/DYN+FR
PP (Watt)	0.976*	0.931*
AP (Watt)	0.979*	0.903*

*p<0,05; **p<0,01, PP: Peak Power, AP: Average Power,

DISCUSSION

Many trainers and coaches use foam rolling self-myofascial release technique with foam roller as a pre-exercises technique to improve athletic performance[35]. While there are a lot of studies used FR intervention as a pre-exercise warm-up technique just alone, there has not been enough information to evaluate pre-exercise FR roller intervention in addition to a dynamic stretching. Therefore, the aim of the current study was to determine the effects of the pre-exercise foam rolling There are limited studies examining the pre-exercise foam roller intervention on anaerobic muscle power in scientific literature. In these studies, while most of the them used the FR intervention without combination with dynamic or static stretching [19,23,24,31,32], only one study used FR intervention in addition to dynamic stretching[35]. Our results are in parallel with Peacock et al. (2014) who compared pre-exercise a total-body dynamic warm-up in addition to a self-myofascial release with foam rolling session with a total body dynamic warm-up (DYN). They found that there were significantly greater performance scores after FR intervention in additional to dynamic warm-up for power (the standing long jump and vertical jump and), agility, strength (1-RM bench press), and speed when compared to DYN session. However, they did not find any differences for the sit and reach test scores between DYN and SMR conditions. Moreover, D'Andrea (2016) demonstrated that isokinetic peak torque intervention in addition to dynamic stretching on anaerobic power. It was hypothesized that the foam roller intervention in addition to the dynamic stretching will be more effective when compared to dynamic stretching without foam rolling on anaerobic power. In the current study, we found that anaerobic average and peak power were greater after pre-exercise foam rolling intervention together with the dynamic stretching when compared with dynamic stretching without foam rolling intervention only in the male group.

significantly increased after the foam roller intervention when compared with the control protocol and the dynamic warm-up protocol ($p<0.01$). In another study, Halperin et al. (2014) examined the effects of pre-exercise a FR intervention and static stretching of the calf muscle on maximal muscle power output. They found that both interventions improved ankle ROM. However, the FR increased, and static stretching decreased maximal force output during the post-test measurements. This was an expected result because there are a lot of studies demonstrating negative effect of static stretching on anaerobic muscle power[6,7,8,9,22].

In contrast to the current study, Healey et al., (2014) compared pre-exercise a series of planking and foam rolling exercises on anaerobic power. However, they did not find any significant differences between FR intervention and planking exercises on power, agility and isometric squat force. Similarly,

MacDonald et al. (2013) measured quadriceps maximal voluntary contraction (MVC) force 2-min before (as control session), and then after 10-min a foam rolling intervention. They did not find any differences between two measurements. In another study, MacDonald et al., (2014) investigated effect of foam-rolling of the thigh and gluteal muscles on vertical jump after 0, 24, 48, and 72 h They found that vertical jump did not increase acutely after the FR intervention. However, vertical jump results were greater after 24 and 48 h when compared with control group. Although no significant improvement was observed in these studies, there was also no performance impairment despite an increase in ROM.

The logical explanation for these results may be that while the FR intervention was used in addition to dynamic stretching in our study, other studies used the FR intervention just alone. The amount of force generated in a single muscle fiber is related to the number of myosin cross-bridges making contact with actin. However, the amount of force exerted during muscle contraction in a group of muscle is complex and depend on many factors: number and types of motor units recruited, the initial length of the muscle and the nature of the neural stimulation of the motor units [36]. It has been determined that dynamic stretching significantly improves anaerobic performance because of elevated ‘‘core’’ body temperature[21,30] and enhanced motor unit excitability and greater number of cross-bridges[7] creating an improved ability for power production[20]. Therefore, we speculated that the foam rollers intervention in addition to the dynamic stretching might help increase length of the muscle, the rate of cross bridges attachment, and neural stimulation. Because neural inhibition is reduced during the foam rolling, so that a better communication occurs from afferent receptors in the connective tissue[4,17]. Therefore, the FR in addition to dynamic stretching might increase recruitment patterning or firing rate associated with the neural stimulation.

Another unique aspect of the current study was to investigate the differences between genders. Anaerobic average and peak power were greater after pre-exercise foam rolling intervention in addition to the dynamic stretching when compared with dynamic stretching without foam rolling intervention in the female group, but it was not statistical. A possible explanation would be that foam roller intervention might impair musculotendinous unit (MTU) and number of cross-bridges in female participants. Because it is well known that females have greater flexibility (ROM) than males [25,26,27] Therefore, having more flexibility might impair power output in female participants.

In conclusion, anaerobic power results after an acute bout of foam rolling in addition to a dynamic stretching was greater when compared to an acute dynamic stretching without foam rolling in male group.

PRACTICAL APPLICATIONS

The FR intervention in combination with dynamic stretching may be a beneficial method to increase anaerobic performance in the male group. Future studies may focus on elite or the professional athletes.

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REFERENCE

1. Anderson R., Wise D., Sawyer T., and Nathanson BH., "Safety and effectiveness of an internal pelvic myofascial trigger point wand for urologic chronic pelvic pain syndrome" *The Clinical journal of pain.* 27.pp.764-768, 2011.

2. Anderson R., Wise D., Sawyer T., Glowe P., and Orenberg EK., "6-day intensive treatment protocol for refractory chronic prostatitis/chronic pelvic pain syndrome using myofascial release and paradoxical relaxation training" The Journal of urology. 185.pp.1294-1299, 2011.

3. Bandy WD., Irion JM., and Briggler M., "The effect of time and frequency of static stretching on flexibility of the hamstring muscles" *Physical therapy. 77*.pp.1090-1096, 1997.

4. Barnes MF., "The basic science of myofascial release: morphologic change in connective tissue" *Journal of Bodywork and Movement Therapies*. 1. pp.231-238, 1997.

5. Behara B., and Jacobson BH., "The Acute Effects of Deep Tissue Foam Rolling and Dynamic Stretching on Muscular Strength, Power, and Flexibility in Division I Linemen" *Journal of Strength & Conditioning Research.* 31. pp.888-892, 2017.

6. Behm DG., Button DC., and Butt JC., "Factors affecting force loss with prolonged stretching" *Canadian Journal of Applied Physiology.26*. pp.262-272, 2001.

7. Behm DG., Bambury A., Cahill F., and Power K., "Effect of acute static stretching on force, balance, reaction time, and movement time" *Medicine& Science & Sports& Exercise*. *36*. pp.1397-1402, 2004.

8. Behm DG., Bradbury EE., Haynes, AT., Hodder JN., Leonard AM., and Paddock NR., "Flexibility is not related to stretch-induced deficits in force or power" *Journal of Sports Science & Medicine*. *5*. pp.33-42, 2006.

9. Behm DG., and Kibele A.," Effects of differing intensities of static stretching on jump performance" *European journal of Applied Physiology. 101.*pp. 587-594, 2007.

10. Behm DG., and Chaouachi A., "A review of the acute effects of static and dynamic stretching on performance" *European journal of Applied Physiology*. *111*. pp. 2633-2651, 2011.

11. Bishop D.," Warm up I" *Sports Medicine*.*33*.pp. 439-454, 2003.

12. Boyle M., Using Foam Rollers. https://www.performbetter.com/using-foam-rollers (2018).

13. Boyle M., Foam rolling. In: Training and Conditioning Magazine. https://www.strengthcoach.com/public/1303.cfm (2018).

14. Castiglione A,, ed. "Self-Myofascial Release Therapy and Athletes" http://www.180degrees.com.au/files/self_myofascial_release_therapy_and_athletes.pdf (2018).

15. Chaouachi A., Castagna C., Chtara M., Brughelli M., Turki O., Galy O., Chamari K., and Behm DG.," Effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals" Journal of Strength & Conditioning Research. 24.pp.2001-2011, 2010.

16. Clark M., and Russell A., Self-myofascial Release Techniques. http://www.PerformBetter.com. (2009).

17. Connolly DA., Sayers SP., and McHugh MP., "Treatment and prevention of delayed onset muscle soreness" *Journal of Strength &Conditioning Research*. 17.pp.197-208, 2003.

18. Curran PF., Fiore RD., and Crisco JJ., "A comparison of the pressure exerted on soft tissue by 2 myofascial rollers" *Journal of Sport Rehabilitation.*17. pp.432– 442, 2008.

19. D'Andrea J., "Foam Rolling as a Novel Warm-up Technique for Anaerobic Power Activities". Doctoral dissertation. The William Paterson University Of New Jersey, 2016

20. Feigenbaum AD., Kang J., McFarland J., Bloom JM., Magnatta J., Ratamess NA., and Hoffman JR., "Acute effects of different warm-up protocols on anaerobic performance in teenage athletes" *Pediatric Exercise Science*.*18*. pp.64-75, 2006.

21. Fletcher IM., and Jones B., "The effect of different warm-up stretches protocols on 20-meter sprint performance in trained rugby union players" *Journal of Strength and Conditioning Research.* 18.pp.885-888, 2004.

22. Fowles JR., Sale DG., and MacDougall JD., "Reduced strength after passive stretch of the human plantar flexors" *Journal of Applied Physiology*.*89*. pp.1179-1188, 2000.

23. Halperin I., Aboodarda SJ., Button DC., Andersen LL., and Behm DG., "Roller massager improves range of motion of plantar flexor muscles without subsequent decreases in force parameters" *International Journal of Sports Physicial Therapy*. 9.pp. 92-102, 2014.

24. Healey KC., Hatfield DL., Blanpied P., Dorfman LR., and Riebe D.," The effects of myofascial release with foam rolling on

performance" *Journal of Strength & Conditioning Research* 28.pp. 61–68, 2014.

25. Hutchinson MR., and Ireland ML., "Knee injuries in female athletes" *Sports Medicine*. *19*.pp. 288-302, 1995.

26. Ireland ML., "The female ACL: why is it more prone to injury?" *Orthopedic Clinics*. 33.pp.637-651, 2002.

27. Knapik JJ., Bauman CL., Jones BH., Harris JM., and Vaughan L., "Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes" *American journal of sports medicine.*19. pp. 76-81, 1991.

28. Lawton J., Pabon R., Kline S., Carter Z., Owens S., Sanders J., and Robinson R., "The Effects of Foam Rolling vs Dynamic Stretching on Anaerobic Performance" *International Journal of Exercise Science: Conference Proceedings*.9. pp.63, 2016.

29. Ma C., Wu S., Li G., Xiao X., Mai M., and Yan T., "Comparison of miniscalpel-needle release, acupuncture needling, and stretching exercise to trigger point in myofascial pain syndrome" *Clinical Journal of Pain*. 26.pp. 251-7, 2010.

30. Mann DP., and Jones MT., "Guidelines to the Implementation of a Dynamic Stretching Program" *Strength & Conditioning Journal. 21*.pp.53. 1999.

31. MacDonald GZ., Penney MD., Mullaley ME., Cuconato AL., Drake CD., Behm DG., and Button DC., "An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force" *Journal of Strength & Conditioning Research*. 27. pp.812-21, 2013.

32. MacDonald GZ., Button DC., Drinkwater EJ., and Behm DG., "Foam rolling as a recovery tool after an intense bout of physical activity" *Medicine and Science in Sports and Exercise.*46.pp.131-142, 2014.

33. Norris. CM., The complete guide to stretching, Human Kinetics Publishing, pp. 23–76, Windsor, 1999

34. Okamoto T, Masuhara M, and Ikuta K., "Acute effects of self-myofascial release using a foam roller on arterial function" The Journal of Strength & Conditioning Research .28.pp.69–73, 2014

35. Peacock CA., Krein DD., Silver TA., Sanders GJ., and Von Carlowitz KPA., "An acute bout of self-myofascial release in the form of foam rolling improves performance testing" *International journal of Exercise Science.*7. p.202, 2014.

36. Powers. CK., and Howley ET. Exercise Physiology (Theory and application to fitness and performance), McGraw-Hill International edition,USA, 2011.

37. Renan R., Alburquerque F., Rodrigues DP., Cleland JA., and Fernández C., "Effectiveness of myofascial trigger point manual therapy combined with a self-stretching protocol for the management of plantar heel pain: a randomized controlled trial" *Journal of Orthopedic and Sports Physical therapy*. *41*.pp. 43-50, 2011

38. Schroeder AN., and Best TM., "Is self-myofascial release an effective pre-exercise and recovery strategy? A literature reviews" *Current Sports medicine reports*. *14*.pp. 200-208, 2015.

39. Young WB., and Behm DG., "Should Static Stretching Be Used During a Warm-Up for Strength and Power Activities?" *Strength and Conditioning Journal*. *24*.pp.33-37, 2002.

40. Young, WB. "The use of static stretching in warm-up for training and competition" *International Journal of Sports Physiology and Performance. 2*.pp.212-216, 2007.