

ACUTE EFFECTS OF STATIC AND DYNAMIC STRETCHING ON LOWER LIMB ENDURANCE AMONG YOUNG ADULTS

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ABSTRACT

Literature on stretching has shown deficits in concrete evidence of the comparison of the effects of static and dynamic stretching on lower limb endurance. The purpose of the current study was to compare the effects of static and dynamic stretching in the young adults in terms of the endurance of lower limb muscles. Forty male young adults were systematically assigned to static or dynamic stretching groups and performed respective stretches according to their group assignment protocols. Participants were recruited from University Tunku Abdul Rahman, Sungai Long Campus. Lower limb endurance was assessed pre and post stretching for both groups using squat test and wall sit test. Hamstrings, quadriceps, and the calf muscles were stretched. The pre-test and post-test values of squat test in the static stretching group was 30.1 ± 5.51 repetitions and 32.75 ± 4.95 repetitions and for wall sit test, subjects demonstrated 84.3 ± 55.68 and 83.6 ± 41.89 seconds. In the dynamic stretching group, the subjects performed an average number of 27.15 ± 6.04 repetitions and 31.9 ± 5.79 repetitions on squat test. On the other hand, the dynamic stretching group was able to put up a mean of 71.95 ± 25.52 and 85.7 ± 33.72 seconds on wall sit pre and post stretching respectively. Significant effect for dynamic stretching was found in both outcome measures ($p > 0.05$). The findings of the current study support the claim that dynamic stretching may be preferable to static stretching as part of a warm-up designed to prepare for physical activity requiring maximal muscle endurance.

Key words: Static stretching, Dynamic stretching, Muscle endurance, Young adults, performance, Lower limb.

INTRODUCTION

Athletes, coaches and sport practitioners regularly include stretching exercises in both training programs and in pre-event warm-up activities. It is widely conjectured that increasing flexibility will promote better performances and reduce the incidence of injury. Stretching has traditionally been recommended with the goal of improving range of motion, athletic performance, decreasing stiffness, and possibly decreasing the risk of injury. However, this concept has been refuted by some studies. Among the stretching techniques applied, the static method is more often practiced in recreational exercises, likely because of its ease and safety. Dynamic stretching has also recently been prescribed by strength and conditioning professionals for pre-event stretching.

The traditional and most common type is static stretching, where a specific position is held with the muscle on tension to a point of a stretching sensation and repeated. Dynamic stretching involves moving a limb through its full range of motion to the end ranges and repeating several times. Static stretching is effective at increasing ROM. The greatest change in ROM with a static stretch occurs between 15 and 30 seconds; and it is suggested that 10 to 30 seconds is sufficient for increasing flexibility. In addition, no increase in muscle elongation occurs after 2 to 4 repetitions. Several authors have found no improvement in performance when comparing static and dynamic stretching. In contrast to static stretching, dynamic stretching is not associated with strength or performance deficits, and actually has been shown to improve dynamometer-measured power as well as jumping and running performance. Notwithstanding the widespread acceptance and use of stretching exercises as a major component of pre-event activities, the purported benefits that stretching has on performance and injury prevention have come into question in several review papers.

According to the evidence on the positive effects of dynamic stretching on physical performance, many trainers advise athletes and novices to perform dynamic stretching instead of static stretching. Recent reports indicate that performing dynamic stretching before exercise helps to increase the range of motion and body temperature which in turn improve performance. It also increases blood flow to active muscles, as a result, lead to faster nerve impulse transmission.

On the other hand, a significant decrease in strength performance was not observed after the application of a static stretching protocol, and static stretching, employed as part of the warm-up section in professional soccer players, did not reduce speed motor capacity. According to Fowles et al., the reason for the decrease in voluntary force production is the depressed motor unit activation, which remains reduced for one hour after static stretching. Franco et al. found a significant reduction above 10 to 12% on endurance performance (with 40% of 1-RM) in bench press exercise after one set of static stretching (40 s) on agonists (PM) when compared to condition without pre-exercise stretching. Usually trainers and designers of resistance training recommend to athletes and participants in the sport events to perform stretching before physical activity as an important part of warm-up to improve maximal muscular performance, decrease muscle damage, reduce muscle soreness and increase joint irritability. Since the subjects of these mentioned studies involved athletes with high level of fitness, their findings cannot be applied in untrained and non-athlete population with low fitness levels. Furthermore, despite use of dynamic stretching by some sports participants, scant research exists on the effects of this mode of stretching on physical performance parameters like endurance that closely relates to the actual demands of sport.

However, studies on acute effects of static and dynamic stretching on muscular endurance in untrained subjects are scarce and contradictory. Therefore, the purpose of this study was to determine the influence of static and dynamic stretching activity on muscle endurance performance. Specifically, the investigation concentrated on whether or not the acute stretching of hamstrings, quadriceps, and the calf muscles would alter the muscular endurance of lower limb.

METHODOLOGY

The quasi-experimental study was designed to include Forty recreationally-active male participants (age 23.17 ± 4.06 years; height 175.64 ± 5.55 cm; weight 67.33 ± 8.26 kg) with no history of diseases and history of diseases and smoking voluntarily participated in this study. No general clinical examination was carried out; however, all subjects are medically examined at the time of admission. The participants were randomly divided into 2 groups; each group comprising 20 subjects. Males between 18 to 25 years with a previous general recreational exercise experience of at least six months were included in the study. The participants had a previous general recreational exercise experience of at least six months. However, none of the subjects were engaged in any regular or structured stretching program. The participants that sustained underlying injury of the lower extremity that causes pain, cardiovascular problems that limit exercise, neurological condition which affects the body's balance and coordination, and high blood pressure of more than 180/100mmHg were excluded from the study. The subjects were allowed to withdraw from the research if the subject does not wish to continue with their participation because of pain or any sign that may increase the risk of the subject's safety. This study was approved by UTAR Scientific and Ethical Review Committee (SERC). Written and

oral consent from each participant was obtained prior to the start of the study after the subjects were informed of any possible risks from the experiment.

This study was conducted at the Sport Facilities and Gym of University Tunku Abdul Rahman, Sungai Long Campus, Malaysia. A privacy curtain was installed to eliminate the visual distractions from gym.

Anthropometric variables: Height (m) and body mass (kg) were measured at the beginning of the first testing session; BMI was calculated by means of the following equation: body mass (kg)/height² (m). A stadiometer (Seca 222; SECA Corp., Hamburg, Germany) and a calibrated bascule (Seca 634; SECA Corp.) were used for this purpose.

The participants were asked to use stationary cycle for 5 minutes which served as a general warm-up. A 5 minute break was given to the participant before carrying out the first round endurance testing that comprised of Squat Test and Wall Sit Test. After performing one of the endurance test, the subject was allowed to rest for 5 minute before the subject proceed to the next endurance test. The order of the endurance tests was counterbalanced to prevent order effect. The number of squats that were performed during the squat test and the duration that the subject can hold the squat position during the wall sit test were recorded. The subject was again allowed to rest for 5 minute before performing stretching exercises. The muscles that stretched were the hamstrings, quadriceps, and the calf muscles. The order of quadriceps, hamstrings and calf muscles stretching were counterbalanced to prevent order effect. Systematic sampling was used where the participants who lies in the odd number in the name selection list will be categorize in the Static Stretching Group and the participants who lies in the even number will be categorize as

the Dynamic Stretching Group. Each stretching group comprised of 20 subjects. We adopted the stretching protocol for lower limb muscles suggested by Yamaguchi and Ishii.¹⁸ The static stretching exercise protocol consisted of three sets of 30 seconds. After 30 seconds, the participant relaxed for 15 seconds and again underwent static stretching of the lower limb muscles (Table 1). Dynamic stretching protocol consisted of three sets of five slow repetitions followed by 10 fast repetitions completed as fast as possible. After each set, the participant was allowed to relax for 15 seconds and then repeated the activity (Table 2). Both endurance tests were performed before and after the stretching exercise protocol. The same investigator completed all testing, and all subjects of each group underwent the same protocol.

TABLE 1

Static Stretching for the targeted muscles.

Calf

Subject is comfortably placed in a supine position with one of the knee fully extended while the examiner dorsiflex the ankle joint of the subject.



Hamstrings

The subject is remain in the supine position with knee fully extend while the examiner flex the hip joint of the subject.



Quadriceps

The subject is placed on a prone position with one of the knee flex and the heel tries to touch the buttock. The knee is lift up such that the hip joint is extending by the examiner.



Table 2
Dynamic Stretching for the targeted muscles

Calf

The subject raises one foot from the floor and fully extends the knee. The subject contracts the dorsiflexors with his own effort and dorsiflex the ankle joint such that the toe is pointing upward.



Hamstrings

The subject contracts the hip flexors by his own effort with knee fully extended and flexes the hip joint such that his leg was swung up to the anterior aspect of his body.



Quadriceps

The subject raises a foot from the floor and lightly flex the hip joint with the knee lightly flex. The subject then contracts the hip extensors by his own effort and extends the hip and knee joints such that his leg is extend to the posterior aspect of the body.



Outcome measures

Squat Test: We followed the Squat Test protocol described by Loudon et al. (2004).¹⁹ Subjects start this test standing with the knees in full extension, shoulder-width apart, and weight evenly distributed on both limbs. The subject lowers his body to a knee position of 90 degree angle and then return to full extension. One repetition consists of a complete cycle of straight standing to 90 angle degrees of knee flexion and return to straight standing. The subject should keep his arms crossed over their chest during the test. The number of squats that are completed in 30 seconds is recorded.

Wall Sit Test: Researchers followed the Wall Sit Test protocol developed by the Tomchuk (2011).²⁰ The subject stands comfortably with feet approximately shoulder width apart, with the

back against a smooth vertical wall. The subjects slowly slide the back down the wall to assume a position with both the subject's knees and hips at a 90 degree angle. The timing starts when the subject leans on the wall while holding the squat position with both legs. The duration that the subject can hold the squat position was recorded.

RESULTS AND DISCUSSION

Forty subjects participated in this study. Following the recruitment process, the subjects were assigned into two groups namely the Static stretching (SS) group and Dynamic stretching (DS) group. There were no drop outs during the trial. Pre and post-test assessments for endurance level were conducted on the same day itself. There were no statistically significant differences between SS and DS group for any pre-test dependent variables measured. Static stretching group comprised of 20 participants with mean age of 20.30 ± 1.26 years, weight 68.80 ± 11.16 kg, height 173.15 ± 7.76 cm and a BMI of 22.96 ± 3.42 . On the other hand, the dynamic stretching group had 20 participants with mean age of 20.35 ± 1.42 years old, weight 66.60 ± 7.90 kg, height 171.85 ± 4.93 cm and a BMI of 22.54 ± 2.51 . Static stretching group performed an average number of 30.1 ± 5.51 repetitions on pretest squat test and 32.75 ± 4.95 repetitions on post-test squat test. (Graph: I). For wall sit test, Static stretching group, the subjects achieved a mean of 84.3 ± 55.68 and 83.6 ± 41.89 seconds on pretest and post-test assessments respectively (Graph: II). Participants of Dynamic stretching group demonstrated an average number of 27.15 ± 6.04 repetitions on pretest assessment and 31.9 ± 5.79 repetitions on post-test assessment of squat test. On the other hand, the Dynamic stretching group demonstrated a mean of 71.95 ± 25.52 and 85.7 ± 33.72 seconds on pre and post-test assessments of wall sit test respectively

(Table:3). A paired sample t-test was performed to compare pre-test and post-test values of the squat test and wall sit test.

TABLE 3

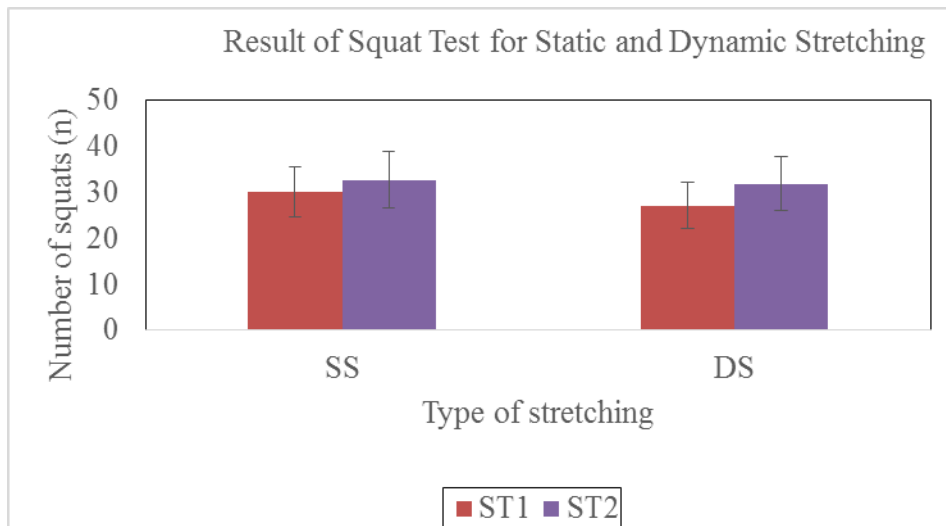
Comparison of pre and post squat test and wall sit test with respect to static stretching and dynamic stretching

| Endurance Test | Static stretching | Dynamic stretching |
|-----------------------|--------------------------|---------------------------|
| Pre Squat Test | 30.1 ± 5.51 | 27.15 ± 6.04 |
| Post Squat Test | 32.75 ± 4.95* | 31.9 ± 5.79* |
| Pre Wall Sit Test | 84.3 ± 55.68 | 71.95 ± 25.52 |
| Post Wall Sit Test | 83.6 ± 41.89 | 85.7 ± 33.72* |

*paired sample t test is performed, level of significant p<0.05

Graph I

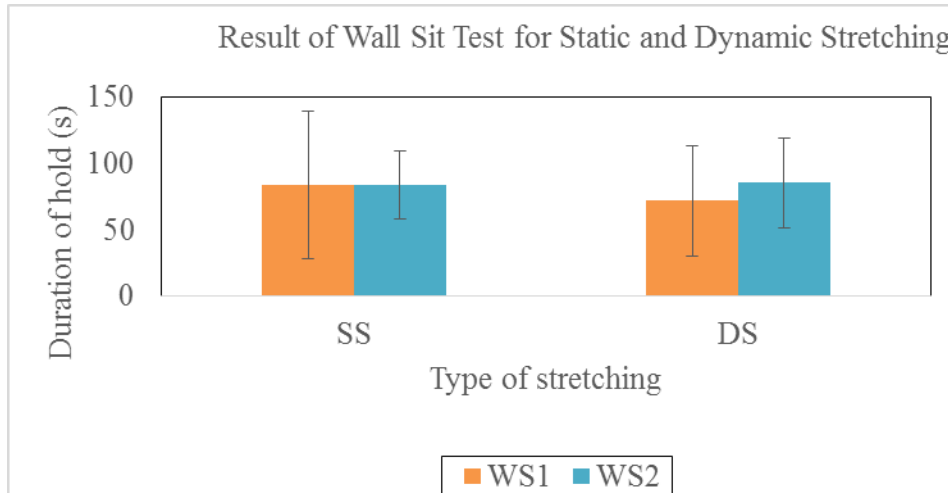
Squat Test Performance in Static and Dynamic Stretching



*paired sample t test is performed, level of significant p<0.05

Graph II

Wall Sit Test Performance in Static and Dynamic Stretching



*paired sample t test is performed, level of significant $p < 0.05$.

Muscular endurance is a parameter that seems to be affected by stretching. Studies have been shown that after static stretching subjects were unable to perform the same number of repetitions for the same load during knee flexion and bench press exercises. This suggests a reduction in endurance. The current study used a multiple-muscle stretching protocol in which participants stretched the major lower-limb muscles) instead of the widely used single-muscle protocol. The rationale for using a multiple-muscle stretching protocol was because an acute bout of static stretching may reduce muscle activation via peripheral (autogenic inhibition of the Golgi tendon reflex, mechanoreceptor and nociceptor afferent inhibition) and central nervous system (supra-spinal fatigue) mechanisms.²¹

The reasons for the poor performance of participants in the static stretching group compared to dynamic stretching group could be due to so-called “stretching-induced strength deficit” due to alterations in the mechanical components of skeletal muscle contraction²²; decreases in muscle activation²³ or a combination of both mechanical and neural factors.²⁴ In contrast, some evidence exists indicating that dynamic stretching exercises may induce improvement in isometric and isokinetic strength and power performance.²⁵ The findings reported by Sekir et al.,²⁶ 2010 have demonstrated that knee flexor and extensor muscles respond in the same way to static and dynamic stretching. Longer recovery periods and lower volumes of static stretching may diminish stretch induced impairments. There are a few studies which presented that blood flow through a muscle can be impaired when stretching exercises was being conducted.²⁷⁻²⁸ Partial ischemia is manifested by the reduced blood flow to the muscles and this leads to force reductions. Discrepancies between the current study design and that of previous studies may explain why the static stretching produced no performance decrements in the present study. Previous protocols have usually stretched muscles for greater durations than those used in common pre-competition warm-ups. Such stretching durations may elicit neural and excessive mechanical force inhibitory mechanisms²⁹ that are not apparent during common pre-competition warm-ups. By using 30-second stretch durations, we may have avoided this effect. Shorter durations of stretching within a warm-up, such as a total stretching duration per muscle of < 30 s may not negatively impact subsequent performance especially if the population is more highly trained.

Although the exact mechanisms by which dynamic stretching may improve strength performance are not well known, previous studies have suggested that a dynamic stretching exercise might

exert positive effects on muscular performance by an elevation of muscular temperature,³⁰ or post-activation potentiation caused by voluntary contractions of the antagonist of the target muscle. Dynamic stretching makes the body continuously moving, even while stretching. The purpose of warming up is to prepare your muscles. Dynamic stretching can accomplish increased muscles core temperature. Dynamic stretching plays a major role in maximizing performance levels and should be a key part of any warm up.³¹ Stretching that includes movement patterns that are involved in the sport will help to prevent injury as the body is prepared for the movements and ranges necessary for the sport. This cannot be achieved with static stretching. Any number of reasons could be responsible for this difference: increased muscle temperature increases neural drive, improved efficiency of contraction, and increased responsiveness of motor units of the muscle. Movements are rehearsed during a dynamic stretch also improving efficiency of movement.³²

The findings of one previous study by Beedle³³ demonstrated that static and dynamic stretching resulted in similar levels of flexibility, however the intensity of warm-up was not the same for the two stretching types, and the results are therefore difficult to compare to our study. However Hayes et al.³⁴ (2007) reported that the running economy of competitive male middle distance runners with an average of 6 years of training was not adversely affected by prior static stretching or dynamic stretching. It is important to acknowledge that endurance is not the only parameter of interest which may be influenced by stretching. There is consistent evidence that dynamic stretching improves performance measures such as agility, speed and strength. Booth et. al.³⁵ suggested that warm-up and stretching immediately pre-participation should focus on performance aspects, rather than improving flexibility and therefore static stretching

should be done at times other than pre-participation. Yamaguchi and Ishii³⁶ compared the power output on a leg press performed after static stretching and dynamic stretching aimed for the quadriceps, hamstrings, gluteus, and calf muscles. The stretching exercises comprised of one set of five stretches for 30 s each, while the dynamic stretching comprised of five slow and 10 fast repetitions of the same stretches. The authors found an improvement of power output with dynamic stretching. They reported that static stretching applied in moderate duration did not affect post-stretching performance, whereas dynamic stretching increased the power developed in the leg press.

Our findings are in accord with another study that compared a dynamic method of stretching to static stretching in runners.³⁶ The findings of this study showed that the dynamic method performed immediately prior to running, improved running speed in a way that was superior to static stretching. Manoel et al³⁷ in 2008 conducted a study to compare the acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. The findings suggest that dynamic stretching may increase acute muscular power to a greater degree than static and PNF stretching. Therefore, the results of the present study indicate that short static and dynamic lower-limb stretching routines do not elicit stretching-induced deficits on lower limb endurance. However, there is some evidence from our findings, in conjunction with similar previous studies, that dynamic stretching is preferable to static stretching as part of a warm-up designed to prepare for physical activity that demands muscular endurance.

Although the current study is the first that has designed and examined the acute effects of a static and dynamic lower limb stretching on lower limb endurance among non-athletes, some limitations should be noted. This study did not directly evaluate changes in the range of motion

or changes in resistance and tolerance to stretch due to the experimental stretching treatments. Therefore it is not known whether the stretching interventions were actually effective in increasing flexibility or in decreasing muscle stiffness.

CONCLUSION

These results would indicate that, overall, stretching routines either dynamic or static, performed can improve endurance of lower limb. Static Stretching routines resulted in marginal increase of endurance and hence dynamic stretching may be useful to maintain muscle performance before a competition. Future research should include more number of samples and integrate functional tasks to determining endurance.

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REFERENCES

- Avela, J., Finni, T., Liikavainio, T., Niemela, E., and Komi, P. V. (2004). Neural and mechanical responses of the triceps surae muscle group after 1 h of repeated fast passive stretches. *J Appl Physiol*; **96**. P. 2325–2332.
- Baechle, T. R. and Earle, R. W. (2008). *Essentials of Strength Training and Conditioning*, 3 Ed., Champaign: Human Kinetics.

- Bandy, W. D., and Irion, J. M. (1994). The effect of time on static stretch on the flexibility of the hamstring muscles. *Phys Ther*; **74(9)**. P. 845-850.
- Beedle, B. B., and Mann, C. L. (2007). A Comparison of Two Warm ups on Joint Range of Motion. *J Strength Cond Res*; **21**. P. 776–779.
- Behm, D. G., Button, D. C. and Butt, J. C. (2001). Factors affecting force loss with prolonged stretching. *Can J Appl Physiol*; **26**. P. 261–272.
- Behm, D. G., and Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. *Eur J Appl Physiol*; **111(11)**. P. 2633-51.
- Bishop, D. (2003). Dynamic Warm up II: Performance changes following active warm up and how to structure the warm up. *Sports Med*; **33**. P. 483–498.
- Booth, L. (2008). Mobility, stretching and warm-up: Applications in sport and exercise. *SportEX Med*; **37**. P. 20–23.
- Costa, P. B., Ryan, E. D., Herda, T. J., Walter, A. A., Defreitas, J. M., and Stout, J. R. (2013). Acute effects of static stretching on peak torque and the hamstrings to quadriceps conventional and functional ratios. *Scand J Med Sci Sports*; **23(1)**. P. 38-45.
- Cramer, J. T., Housh, T. J., Johnson, G. O., Miller, J. M., Coburn, J. W., and Beck, T. W. (2004). Acute effects of static stretching on peak torque in women. *J Strength Cond Res*; **18**. P. 236–241.

Cramer, J. T., Housh, T. J., Weir, J. P., Coburd, J. W., Beck, T. W., and Johnson, G. O. (2004).

Acute effects of static stretching on torque, power, electromyography, and mechanomyography during eccentric muscle actions. *Med Sci Sports Exerc*; **36**. P. S342.

Cramer, J. T., Beck, T. W., Housh, T. J., Massey, L. L., Marek, S. M., and Danglemeier, S.

(2007). Acute effects of static stretching on characteristics of the isokinetic angle–torque relationship, surface electromyography, and mechanomyography. *J Sports Sci*; **25**. P. 687–698.

Fardy S. (2017). The Benefits of Dynamic Stretching vs. Static Stretching

<http://www.bodyscapesfitness.com/the-benefits-of-dynamic-stretching-vs-static-stretching/>Retrieved on 11 March 2017.

Fowles, J. R., Sale, D. G. and Macdougall, J. D. (2000). Reduced strength after passive stretch of

the human plantarflexors. *J. Appl. Physiol*; **89**. P. 1179–1188.

Franco, B. L., Signorelli, G. R., Trajano, G. S., and Oliveira, C. G. (2008). Acute effects of

different stretching exercises on muscular endurance. *J Strength Cond Res*; **22(6)**. P. 1832-7.

Gambetta, V. (1999). Hard core training; a functional approach. *Training Conditioning*; **9**. P. 34-

40.

Hayes, P. R., (2007). Walker A. Pre-exercise stretching does not impact upon running economy.

J Strength Cond Res; **21**. P. 1227–1232.

- Herbert, R. D. and Gabriel, M. (2002). Effects of stretching before and after exercising on muscle soreness and risk of injury: Systematic review. *BMJ*; **325**. P. 468–470.
- Kortney, J., Shala, E., Gregory, B. and Gavin, L. (2010). Effect of static and dynamic stretching on vertical jump performance in collegiate women volleyball players, *J Strength Cond Res*; **24**. P. 149-155.
- Little, T., and Williams, A. G. (2006). Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J Strength Cond Res*; **20(1)**. P. 203-7.
- Loudon, J., Gajewski, B., Goist-Foley, H. and Loudon, K. (2004). The effectiveness of exercise in treating patello-femoral pain syndrome. *J. Sport Rehabil*; **13(4)**. P. 323-342.
- Manoel, M. E., Harris-Love, M. O., Danoff, J. V., and Miller, T. A. (2008). Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. *J Strength Cond Res*; **22**. P. 1528–1534.
- Molacek, D., Conley, S., Evetovich, K., and Hinnerichs, R. (2013). Effects of low-and high-volume stretching on bench press performance in collegiate football players. *J Strength Cond Res*; **24**. P. 711-716.
- Nelson, A. G. and Kokkonen, J. (2001). Acute ballistic muscle stretching inhibits maximal strength performance. *Res Q Exerc Sport*; **72**. P. 415–419.

Pearce, A. J., Kidgell, D. J., Zois, J., and Carlson, J. S. (2009). Effects of secondary warm up following stretching. *Eur J Appl Physiol*; **105**(2). P. 175-183.

Poole, D. C, Musch, T. I. and Kindig C. A. (1997). In vivo microvascular structural and functional consequences of muscle length changes. *Am. J. Physiol*; **272**. P. 2107–2114.

Sekir, U., Arabaci, R., Akova, B., and Kadagan, S. M. (2010). Acute effects of static and dynamic stretching on leg flexor and extensor isokinetic strength in elite women athletes. *Scand J Med Sci Sports*; **20**. P. 268–281.

Stretching-exercises-guide.com. (2017). Dynamic Stretching <http://www.stretching-exercises-guide.com/dynamic-stretching.html>. Retrieved on 11 March 2017.

Taylor, D. C., Dalton, J. D. Jr., Seaber, A. V., and Garrett, W. E. (1990). Viscoelastic properties of muscle-tendon units. The biomechanical effects of stretching. *Am J Sports Med*; **18**(3). P. 300-309.

Thacker, S. B., Gilchrist, J., Stroup, D. F. and Kimsey, C. D. (2004). The impact of stretching on sports injury risk: a systematic review of the literature. *Med Sci Sports Exerc*; **36**. P. 371–378.

Tomchuk, D. (2011). Companion guide to measurement and evaluation for Kinesiology. Sudbury, MA: *Jones and Bartlett Learning*.

Torres, E. M., Kraemer, W. J., and Vingren, J. L. (2008). Effects of stretching on upper-body muscular performance. *J Strength Cond Res*; **22**(4). P. 1279-1285.

- Weldon, S. M. and Hill, R. H. (2003). The efficacy of stretching for prevention of exercise-related injury: a systematic review of the literature. *Manage Ther*; **8**. P. 141–150.
- Wisnes, A., and Kirkebo, A. (1976). Regional distribution of blood flowing calf muscles of rat during passive stretch and sustained contraction. *Acta Physiol Scand*; **96**. P. 256–266.
- Yamaguchi, T. and Ishii, K. (2008). Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. *J Strength Cond Res*; **19**. P. 677-683.
- Yamaguchi, T., Ishii, K., Yamanaka, M. and Yasuda, K. (2007). Acute effects of dynamic stretching exercise on power output during concentric dynamic constant external resistance leg extension. *J Strength Cond Res*; **21**. P. 1238- 1244.
- Young, W., Clothier, P., Otago, L., Bruce, L., and Liddell, D. (2004). Acute effects of static stretching on hip flexor and quadriceps flexibility, range of motion and foot speed in kicking a football. *J Sci Med Sport*; **7(1)**. P. 23-31.