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The Jerzy Kukuczka Academy of Physical Education in Katowice
Faculty of Physical Education and Sport, Charles University in Prague

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Impact of static stretching on the one-repetition maximum test results in the barbell half squat among amateur bodybuilders

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Grzegorz Wojdała [ABDEF], Monika Papla [ABC], Paulina Królikowska [AE], Joanna Starzak [BCE], Michał Krzysztofik[AE]

Institute of Sport Sciences
The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland

abstract

Background: The level of absolute strength is critical to performance in many sports, especially strength sports. The aim of this study was to examine the effect of static stretching before resistance exercise on the level of absolute strength.

Material and methods: The study involved fourteen (14) strength trained men, amateur bodybuilders (age = 21.5 ±0.9 years, body mass = 88.5 ±7.2kg) with a minimum two year of strength training experience. The results of the 1-RM test for barbell half-squat were used. The test consisted of performing a half-squat exercise according to the test protocol with the load increased every set until the maximum load was reached. Starting from a load of approximately 70% of the anticipated 1-RM, the participants executed single repetitions with a 5 min rest interval between successful trial. Each subsequent attempt was increased by 2.5 to 10kg, and the process was repeated until the load of 1RM was reached.

Results: The analysis showed that stretching before training reduced the maximum weight lifted by the study participants on the average by 4.3 ±3kg.

Conclusions: The results indicate a negative effect of static stretching on absolute strength, evaluated by the barbell half squat. The authors suggest that stretching should be avoided before resistance training with maximum loads.

Key words: resistance exercise, strength, flexibility, warm-up, stretch, range of motion.

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Corresponding author: Grzegorz Wojdała, Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland, 40-065, Mikolowska str. 72a, Katowice, Poland; e-mail: wojdala.grzegorz@gmail.com

INTRODUCTION

Muscle strength is one of the basic motor abilities of every human being. They are defined as a theoretical construct that specifies a set of individual properties determined by the structure of the system, energy processes and processes of movement control and regulation, which directly characterize the level of performance of a specific type of motor activity. Every person has to use their strength in almost all performed actions, both consciously on a daily basis (in human locomotion) and unconsciously (e.g. during body stabilization and breathing) [1]. Muscle strength is the ability to produce external force by muscle contraction [2]. Similarly to most human abilities, strength has been divided into many components by different authors [3–5]. The basic unit of generated force is Newton, and this was the basis for division of strength into three components [6]. Absolute muscle strength refers to the maximum tension level that a muscle group can produce [7], regardless of its size. From the holistic standpoint, this is the maximum weight that a person is able to lift during a specific exercise. In interpersonal comparisons, the most reliable and appropriate approach is to use the concept of relative strength, i.e. the level of absolute strength related to 1 kg of body weight. The most commonly used test, also considered as the gold standard, to assess absolute strength levels is 1RM test. It can be defined as the maximal load that can be lifted once with correct form, over a specific range of motion, is comparatively simple and requires relatively inexpensive non-laboratory equipment [8, 9].

Flexibility, together with muscular strength, seems to be a fundamental fitness component in many sports activities and even for common daily motor tasks [10]. It defines the range of movement in a single joint or several joints [11]. Flexibility is also related to the ability to perform smooth movements over the entire range of motion in the joint [12]. Effective training interventions allowing an increase in flexibility and muscle extensibility may be static, dynamic or pre-contraction 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 [13].

Research shows that performing static stretching before training during the warm-up has its supporters [14, 15]. Some authors confirm the legitimacy of using this type of intervention in specific cases. In order to improve the range of motion during exercise, no differences were found between static and dynamic stretching preceding activity [16]. There is also evidence of no change in the power level or speed if active warm-up and high-intensity sport-specific skills-based activity were included after static stretching [17, 18]. Stretching can also affect motivation and psychological parameters. A study by Park et al. [19] shows that warm-up containing elements of static stretching seem to have a meaningful effect on athletic performance by affording psychological stability, preparation, and confidence for exercise performance. However, it still needs to be considered that exercise intensity can result in increased mental focus [20]. In general, it appears that static stretching is most beneficial for athletes requiring flexibility for their sports (e.g. gymnastics, dance, etc.). Dynamic stretching may be better suited for athletes requiring running or jumping performance during their sport, such as basketball players or sprinters [13].

However, many authors deny the use of static stretching during the warm-up before exercise. Studies have shown that body flexibility decreases at low temperature by 10–20%, whereas a rise in temperature causes an increase in the range of motion even by 20% of the baseline value [21], which is important in the early stages of warming up. The reduced ability to rebuild skeletal muscles after stretching exercises has also been confirmed [22]. Another hypothesis is based on a decrease in the strength of muscle contraction by reducing the number of actin-myosin cross bridges that are formed. The extensibility of tendons and muscles also increases, which results in a decrease in the ability to accumulate elastic energy. It leads to a reduction in the effectiveness of SSC (stretch-shortening cycle) and, as a result, manifests itself in a decrease in muscle endurance. Although muscle contraction strength increases with active muscle lengthening, yet after exceeding the optimal length (caused by excessive stretching), the contraction force decreases significantly [23]. Contraindications to the use of static stretching before exercise are also due to changes in the mechanical properties of the muscle, such as an altered length-tension relationship, or a central nervous system inhibitory mechanism. As a result, static stretching impairs the production of the maximum force [24].

Many scientific studies have analyzed the influence of various types of stretching used during warm-up. Furthermore, many athletes confirm using static stretching in warm-up routine. Despite the fact that static stretching seems to be inadvisable before resistance training, the authors point out the possible benefits of its use in specific cases. The aim of the study was to determine the effect of static stretching exercises applied during warm-up prior to barbell half squat on 1RM test results. Our initial hypothesis was that the stretching has a significant impact on the maximal load in the 1RM test.

MATERIAL AND METHODS

participants

The study involved fourteen (14) strength trained men, amateur bodybuilders (age = 21.5 ±0.9 years, body mass = 88.5 ±7.2 kg, estimated 1-RM in the barbell half squat = 130.7 ±17.3 kg) with a minimum of two years' strength training experience (4.1 ±1.7 years). The participants were allowed to withdraw from the experiment at any moment and were free of any pathologies or injuries. The subjects were instructed not to perform maximum strength exercises during the week preceding the research and they were acquainted with the course of the research. Procedures were approved by the Research Ethics committee of The Jerzy Kukuczka Academy of Physical Education in Katowice.

procedures

The experiment was performed following a randomized crossover design, where each subject performed familiarization sessions, and two experimental sessions: one with included static stretching exercises in the warm-up protocol and one without. The entire research procedure lasted 3 weeks with a one-week interval between each trial. During the experimental sessions, subjects performed one repetition maximum tests (1RM) in barbell half squat. Subjects were required to refrain from resistance training 72 hours prior to each experimental session, were familiarized with the exercise protocol and were informed about the benefits and potential risks of the study, before providing their written informed consent to participation. All testing sessions was performed in the Strength and Power Laboratory at the Academy of Physical Education in Katowice.

familiarization session and 1RM strength test

One week before the main experiment, the familiarization session preceded the 1RM in barbell half squat. Prior to the 1RM estimation, participants were re-evaluated for their technical execution of barbell half squat. In order to maintain the correctness of performed exercise, 90° knee angle was measured with a digital goniometer. The participants arrived at the laboratory at the same time of day as the upcoming experimental sessions and cycled on an ergometer for 5 minutes, followed by a general upper body warm-up of 10 body weight pull ups and 15 body weight push-ups. Next, the participants performed 15, 10, and 5 BP repetitions using 20%, 40%, and 60% of their estimated 1RM. The load was started from 80% estimated 1RM, and was increased by 2.5 to 10 kg for each subsequent attempt, and the process was repeated until failure. During the 1RM test, the subjects executed one repetition with a 5 min rest interval between successful trials. The participants were additionally verbally motivated to make the maximum effort. No knee wraps, weightlifting belts, or other supportive garments were permitted. Three spotters were present during all attempts to ensure safety and technical proficiency.

experimental sessions

The participants arrived at the laboratory at the same time of day of each experimental session. Two testing sessions were used for the experimental trials. One of the experimental session included a warm-up protocol from the familiarization session extended with static stretching exercises. Static stretching consisted of the execution of three sets of static stretching exercises after the general warm-up (seated hamstring stretch, standing quadriceps stretch and seated calf stretch). The total time of stretching was 10 minutes. Each exercise was performed three times and consisted of 45 s of stretching and 15 s of muscle relaxation. The warm up protocol during the second experimental session was not preceded by static muscle stretching exercises. After each warm-up protocol, participants performed the same 1RM tests in barbell half squat.

statistical analyses

The following methods were used in the analysis of the results, which allowed for the determination of accuracy and reliability of the tests. The descriptive statistics included the standard deviation, skewness, and kurtosis. In order to estimate the real value, the test of significance between the differences was used to compare variables (the Student's t-test for dependent groups). The values were generated by means of PQStat and Microsoft Office.

RESULTS

The first test included only 1-RM measurement (RM_{NO-SS}), while the second test consisted of static stretching and the 1-RM measurement (RM_{SS}). Significant differences were observed in the level of maximum strength between the RM_{NO-SS} and the RM_{SS} ($P < 0.05$). In all valid tests, the mean in RM_{NO-SS} was 4.3 ±3kg higher than in RM_{SS}. The minimum weight lifted in RM_{NO-SS} was 15kg higher than in RM_{SS} at the same maximum weight.

Table 1. Descriptive statistics for the results of dependent samples obtained by each participant

Test	N valid	Mean 1-RM (kg) ± SD	P value	Effect size
RM_{NO-SS}	14	133.2 ±16	0.028*	-0.26
RM_{SS}	14	128.9 ±16.78		

The graph comparing the results obtained by the study participants in both trials shows a tendency for absolute strength to decrease or remain unchanged following stretching.

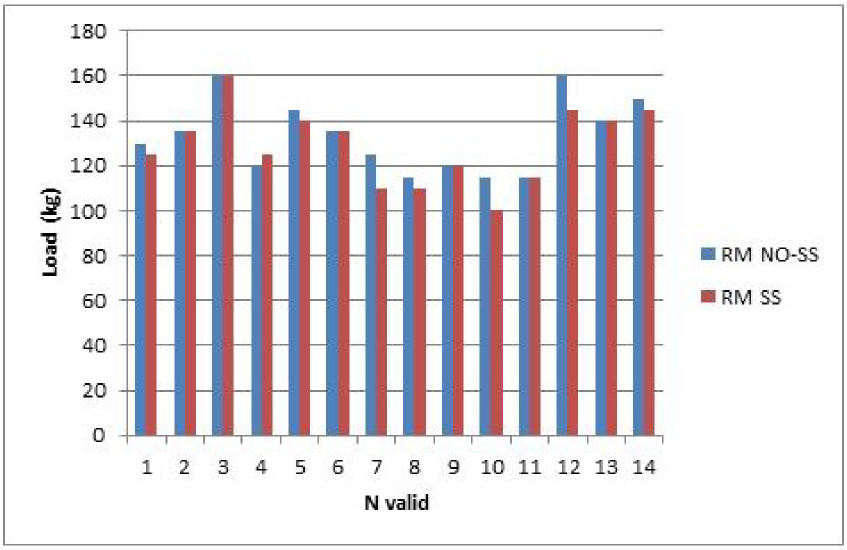

Figure 1. 1-RM test results obtained in RM_{NO-SS} and RM_{SS}

Similar conclusions can be drawn from analysis of a graph comparing the average results of both trials (taking into account the 95% confidence interval). A decline in the load lifted was noticeable in RM_{SS} where stretching preceded strength evaluations.

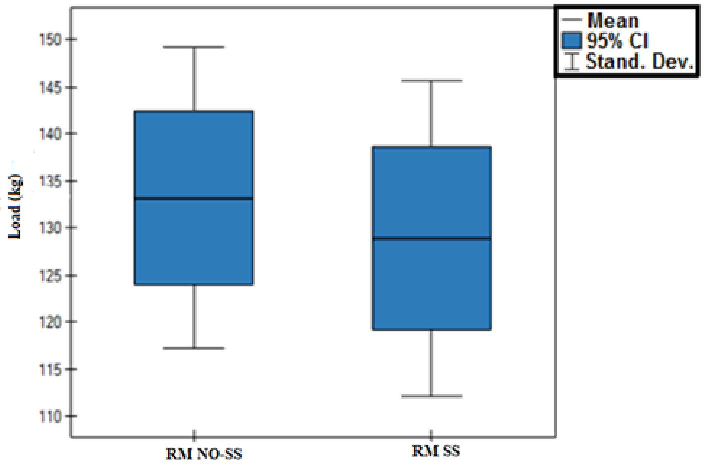

Figure 2. Comparison of mean results of RM_{NO-SS} and RM_{SS}

DISCUSSION

The main finding of the present study is the existence of significant differences in the absolute strength in the 1RM test protocol between particular warm-up protocols. The result of the 1RM test preceded by warm-up containing static stretching (RM_{SS}) was significantly lower compared to the warm-up without stretching (RM_{NO-SS}). The results of our study showed a negative effect of using static stretching exercises prior to resistance training with a maximum load what confirmed our hypothesis.

The results are consisted with previous studies confirming an acute loss of strength after stretching [1, 25, 26]. The loss of strength resulting from acute static stretching has been termed "stretch-induced strength loss" [27]. However, it should be noted that most testing protocols consisted of an isolated exercise involving only a specific muscle group. Nevertheless, the present study including the multi-joint exercise, barbell half squat, leads to similar conclusions. The reason for the occurrence of strength loss is not clear. According to the authors, neural factors [17, 18, 28] or mechanical factors [1, 25, 26] can cause this phenomenon. Siatras et al. [29] point to the influence of the length of static stretching on a decrease in muscle strength. In this study stretching reduced the isometric peak torque by 8.5% and 16.0%, respectively. Concerning the isokinetic peak torque after 30 and 60 seconds of stretching, it was reduced by 5.5% vs. 11.6% at 60 degrees/s and by 5.8% vs. 10.0% at 180 degrees/s. It seems possible that reducing the stretching time to a maximum of 30 seconds can reduce the effects of strength loss [30].

Although many scientific studies present the adverse effects of static stretching preceding physical exercises, there is public conviction about injury prevention related to stretching [31]. The beneficial, acute effects of static stretching on the reduction of injury rates or the speed and strength of muscle contraction seem to be unlikely [32]. Studies have also suggested an adverse or negligible effect of static stretching on the reduction of injury risk during exercise [33]. Excessive stretching can lead to micro-injuries of muscle fibers, reduced muscle stiffness leading to increased fiber susceptibility to damage, and to "hidden" muscle pain, which can result in serious injuries if the exercise is continued [34]. Current research indicates the beneficial effects of dynamic stretching in warm-up, whereas static stretching, which reduces the strength of muscle contraction due to reduced formation of actin-myosin cross bridges, is claimed to lead to negative effects [35, 36]. The reduced injury risk is mainly based on the concept of increased blood circulation and muscle temperature due to a proper warm-up procedure, rather than on stretching exercises. However, some authors confirm the effectiveness of stretching in preventing specific types of injury. A study by Amako et al. [37] suggests that static stretching decreased the incidence of muscle-related injuries but did not prevent bone or joint injuries. Furthermore, it seems reasonable to use stretching exercises that include additional post-stretching dynamic activity for increasing the range of motion, accelerating recovery and reducing the risk of injury [38].

Despite numerous indications, the concept of applying static stretching before exercise should not be completely rejected. The authors point to the positive aspects of static stretching in terms of increasing the range of motion [38] or psychological stability and confidence [19]. Some studies that evaluated the kinematic parameters of specific sports tasks indicate that there are no contraindications for static stretching before football [39], tennis [40] or baseball activities [41]. A number of methodological issues, or multiple variations of stretching programs following different structures of protocols (modes, intensities, frequencies, durations of stretches, recovery prior to performance) may have an impact on the discrepancy in the results showing that static stretching in different sports did not have a significant effect on specific sport kinetic performance [6]. This may result from differences in body composition, sports skill level, somatic type, baseline level of strength and conditioning or other factors.

Recommendations for stretching exercises result from all previously presented relationships. Over the years, a pattern that recommends performing dynamic stretching exercises before speed and strength training (during warm-up) and static stretching during the cool down of a training session has been developed. Performing flexibility training immediately before resistance training can contribute to a lower number of repetitions, total volume, and muscle hypertrophy [42]. The best effects seem to be obtained by performing dynamic stretching exercises in the second stage of the warm-up, after a significant increase in body temperature [43]. It seems reasonable to use static exercises in certain cases of sport activities, bearing in mind that this type of stretching should be avoided in trainings focused on the development of strength.

CONCLUSIONS

With reference to the conducted tests, it can be stated that static stretching before training might have a negative effect on the level of absolute strength. A decrease in absolute strength following the introduction of static stretching exercises during the warm-up was found in most participants. It is reasonable to say that static stretching exercises should be avoided before training or before competitions because there is very little chance that they would lead to achieving better results. Instead, the authors propose a general warm-up, composed of aerobic exercises and dynamic stretching [22, 34, 38].

There may be some possible limitations in this study. The size of the group may be insufficient. Subsequent research should include athletes from other sport disciplines, with both female and male athletes. Maximum strength can also be evaluated through other exercises or specialized equipment [44].

REFERENCES

[1] Nelson A, Driscoll N, Landin D, Young M, Schexnayder I. Acute effects of passive muscle stretching on sprint performance. J Sports Sci. 2005;23(5):449-454. https://doi.org/10.1080/02640410410001730205

[2] Golas A, Maszczyk A, Zajac A, Mikolajec K, Stastny P. Optimizing post activation potentiation for explosive activities in competitive sports. J Hum Kinet. 2016;52:95-106. https://doi.org/10.1515/hukin-2015-0197

[3] Mikolajec K, Poprzecki S, Zajac A, Cholewa J. Effects of warm-up intensity on anaerobic performance. J Hum Kinet. 2007;7:41-52.

[4] Poprzecki S, Zajac A, Wower B, Cholewa J. The effects of a warm-up and the recovery interval prior to exercise on anaerobic power and acid-base balance in man. J Hum Kinet. 2007;18:15-27.

[5] Mikolajec K, Maszczyk A, Stanula A, Litkowycz R, Zajac A. Stretching and strength exercises in relation to running speed and anaerobic power in basketball players. Antropomotoryka. 2012;57:17-25.

[6] Mikolajec K, Waskiewicz Z, Maszczyk A, Bacik B, Kurek P, Zajac A. Effects of stretching and strength exercises on speed and power abilities in male basketball players. Isokinet Exerc Sci. 2012;20(1):61-69. https://doi.org/10.3233/IES-2012-0442

[7] De Lira C, Vargas V, Silva W, Bachi A, Vancini R, Andrade M. Relative Strength, but Not Absolute Muscle Strength, Is Higher in Exercising Compared to Non-Exercising Older Women. Sports (Basel). 2019;7(1):19. https://doi.org/10.3390/sports7010019

[8] Kraemer WJ, Ratamess NA, Fry AC, French DN. Strength testing: development and evaluation of methodology. In: Maud PJ, Foster C, editors. Physiological assessment of human fitness. 2nd ed. Champaign, IL: Human Kinetics; 2006,119-150.

[9] Wilk M, Krzysztofik M, Gepfert M, Poprzecki S, Golas A, Maszczyk A. Technical and training related aspects of resistance training using blood flow restriction in competitive sport – A review. J Hum Kinet. 2018;65:249-260. https://doi.org/10.2478/hukin-2018-0101

[10] Rubini EC, Costa AL, Gomes PS. The effects of stretching on strength performance. Sports Med. 2007;37(3):213-224.

[11] Borms J, Van Roy P. Flexibility. In: Eston R, Reilly T, editors. Kinanthropometry and exercise physiology. Laboratory manual. 3rd ed. London; New York: Routledge; Taylor & Francis Group; 2009,129-159.

[12] Heyward VH. Advanced Fitness Assessment and Exercise Prescription. Champaign: Human Kinetics; 1997.

[13] Page P. Current concepts in muscle stretching for exercise and rehabilitation. Int J Sports Phys Ther. 2012;7(1):109-119.

[14] Judge LW, Bellar DM, Gilreath EL et al. An examination of preactivity and postactivity stretching practices of NCAA division I, NCAA division II, and NCAA division III track and field throws programs. J Strength Cond Res. 2013;27(10):2691-9. https://doi.org/10.1519/JSC.0b013e318280c9ac

[15] Popp JK, Bellar DM, Hoover DL, Craig BW, Leitzelar BN, Wanless EA, Judge LW. Pre- and Post-Activity Stretching Practices of Collegiate Athletic Trainers in the United States. J Strength Cond Res. 2017;31(9):2347-2354. https://doi.org/10.1519/JSC.0000000000000890

[16] Curry BS, Chengkalath D, Crouch GJ, Romance M, Manns PJ. Acute effects of dynamic stretching, static stretching, and light aerobic activity on muscular performance in women. J Strength Cond Res. 2009;23(6):1811–1819. https://doi.org/10.1519/JSC.0b013e3181b73c2b

[17] Ce E, Margonato V, Casasco M, Veicsteinas A. Effects of stretching on maximal anaerobic power: the roles of active and passive warm-ups. J Strength Cond Res. 2008;22(3):794-800. https://doi.org/10.1519/JSC.0b013e31816a4353

[18] Taylor KL, Sheppard JM, Lee H, Plummer N. Negative effect of static stretching restored when combined with a sport specific warm-up component. J Sci Med Sport. 2009;12(6):657-661. https://doi.org/10.1016/j.jsams.2008.04.004

[19] Park HK, Jung MK, Park E, et al. The effect of warm-ups with stretching on the isokinetic moments of collegiate men. J Exerc Rehabil. 2018;14(1):78-82. https://doi.org/10.12965/jer.1835210.605

[20] Stastny P, Golas A, Blazek D et al. A systematic review of surface electromyography analyses of the bench press movement task. PLoS One. 2017;12(2):1-16. https://doi.org/10.1371/journal.pone.0171632

[21] Petrofsky JS, Laymon M, Lee H. Effect of heat and cold on tendon flexibility and force to flex the human knee. Med Sci Monit. 2013;19:661-667. https://doi.org/10.12659/MSM.889145

[22] Gergley JC. Acute effect of passive static stretching on lower-body strength in moderately trained men. J Strength Cond Res, 2013;27(4):973-977. https://doi.org/10.1519/JSC.0b013e318260b7ce

[23] Herzog W. Why are muscles strong, and why do they require little energy in eccentric action? J Sport Health Sci. 2018;7(3):255-264. https://doi.org/10.1016/j.jshs.2018.05.005

[24] 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. 2004;18:236-241. https://doi.org/10.1519/00124278-200405000-00006

[25] Herda TJ, Cramer JT, Ryan ED, McHugh MP, Stout JR. Acute effects of static versus dynamic stretching on isometric peak torque, electromyography, and mechanomyography of the biceps femoris muscle. J Strength Cond Res. 2008;22(3):809-817. https://doi.org/10.1519/JSC.0b013e31816a82ec

[26] McHugh MP, Nesse M. Effect of stretching on strength loss and pain after eccentric exercise. Med Sci Sports Exerc. 2008;40(3):566-573. https://doi.org/10.1249/MSS.0b013e31815d2f8c

[27] McHugh MP, Cosgrave CH. To stretch or not to stretch: the role of stretching in injury prevention and performance. Scand J Med Sci Sports. 2010;20(2):169-181

[28] Behm D, Button DC, Butt JC. Factors affecting force loss with prolonged stretching. Can J Appl Physiol. 2001;26(3):262-272. https://doi.org/10.1139/h01-017

[29] Siatras TA, Mittas VP, Mameletzi DN, Vamvakoudis EA. The duration of the inhibitory effects with static stretching on quadriceps peak torque production. J Strength Cond Res. 2008;22(1):40-46. https://doi.org/10.1519/JSC.0b013e31815f970c

[30] Ogura Y, Miyahara Y, Naito H, Katamoto S, Aoki J. Duration of static stretching influences muscle force production in hamstring muscles. J Strength Cond Res. 2007;21(3):788-92. https://doi.org/10.1519/00124278-200708000-00023

[31] Wilke J, Vogel O, Vogt L. Why are you running and does it hurt? Pain, motivations and beliefs about injury prevention among participants of a large-scale public running event. Int J Environ Res Public Health. 2019;16(19):3766. https://doi.org/10.3390/ijerph16193766

[32] Thacker SB, Gilchrist J, Stroup DF, Kimsey CD. The impact of stretching on sports injury risk: A systematic review of the literature. Med Sci Sports Exerc. 2004;36(3):371-378. https://doi.org/10.1249/01.MSS.0000117134.83018.F7

[33] Small K, Mc Naughton L, Matthews M. A systematic review into the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injury. Res Sports Med. 2008;16(3):213-231. https://doi.org/10.1080/15438620802310784

[34] Cramer J, Housh T, Weir J, Johnson G, Coburn J, Beck T. The acute effects of static stretching on peak torque, mean power output, electromyography, and mechanomyography. Eur J Appl Physiol. 2005;93(5-6):530-9. https://doi.org/10.1007/s00421-004-1199-x

[35] Fowles JR, Sale DG, MacDougall JD. Reduced strength after passive stretch of the human plantar flexors. J Appl Physiol. 2000;89:1179-1188. https://doi.org/10.1152/jappl.2000.89.3.1179

[36] Kokkonen J, Nelson AG, Cornwell A. Acute muscle stretching inhibits maximal strength performance. Res Q Exerc Sport. 1998;69(4):411-415. https://doi.org/10.1080/02701367.1998.10607716

[37] Amako M, Oda T, Masuoka K, Yokoi H, Campisi P. Effect of static stretching on prevention of injuries for military recruits. Mil Med. 2003;168(6):442-446. https://doi.org/10.1093/milmed/168.6.442

[38] Behm D, Blazevich A, Kay A, McHugh M. Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: A systematic review. Appl Physiol Nutr Metab. 2016;41(1):1-11. https://doi.org/10.1139/apnm-2015-0235

[39] Young W, Clothier P, Otago L, Bruce L, Liddell D. 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. 2004;7(1):23-31. https://doi.org/10.1016/S1440-2440(04)80040-9

[40] Knudson DV, Noffal GJ, Bahamonde RE, Bauer JA, Blackwell JR. Stretching has no effect on tennis serve performance. J Strength Cond Res. 2004;18(3):654-6. https://doi.org/10.1519/00124278-200408000-00047

[41] Haag SJ, Wright GA, Gillette CM, Greany JF. Effects of acute static stretching of the throwing shoulder on pitching performance of national collegiate athletic association division III baseball players. J Strength Cond Res. 2010;24(2):452-7. https://doi.org/10.1519/JSC.0b013e3181c06d9c

[42] Junior RM, Berton R, de Souza TM, Chacon-Mikahil MP, Cavaglieri CR. Effect of the flexibility training performed immediately before resistance training on muscle hypertrophy, maximum strength and flexibility. Eur J Appl Physiol. 2017;117(4):767-774. https://doi.org/10.1007/s00421-016-3527-3

[43] Iwata M, Yamamoto A, Matsuo S, Hatano G, Miyazaki M, Fukaya T, Suzuki S. Dynamic stretching has sustained effects on range of motion and passive stiffness of the hamstring muscles. J Sports Sci Med. 2019;18(1):13-20.

[44] Krol H, Golas A. Effect of Barbell Weight on the Structure of the Flat Bench Press. J Strength Cond Res. 2017;31(5):1321-1337. https://doi.org/10.1519/JSC.0000000000001816

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