Viref Revista de Educación Física
Instituto Universitario de Educación Física y Deporte
ISSN 2322-9411 • Enero-Marzo 2023 • Volumen 12 Número 1
UNIVERSIDAD DE ANTIOQUIA 1803

Acute effects of five different stretching exercise protocols on speed and agility

Ali Erdem Cigerci, Harun Genc, Veli Volkan Gurses, Ozan Sever, Ozcan Kızılbag

Information about the authors

Abstract

Objective: to investigate the acute effects of five different stretching protocols applied during the warm-up on speed and agility. **Method:** the sample group consisted of 30 male participants. Participants performed five different stretching models during the warm-up on five non-consecutive days. Performance tests were performed without stretching (NS) and as static (SG), dynamic (DG), static+dynamic (SDG) and dynamic+static (DSG) after 5 minutes of jogging. Sprint and agility tests were applied after each stretching exercise. Repeated Measures ANOVA test was performed to determine the effect of five different stretching exercises on speed and agility. **Results:** the differences between the protocols were as follows NS with DS, SS with DS, DS with SDS, DS with DSS, SDS with DSS in 10 m ($p<0,05$). Besides, there appears to be a statistical difference between NS with DS, SS with DS, DS with SDS, DS with DSS in 20 m ($p<0,05$). There is a statistical difference between NS with DS, SS with DS, DS with SDS, DS with DSS, SDS with DSS in Illinois agility test ($p<0,05$). There is a statistically significant between NS with DS, SS with DS, DS with SDS, DS with DSS in Reactive agility test ($p<0,05$). **Conclusion:** dynamic stretching types should be preferred more before activities that require speed and strength. Therefore, in order to increase the speed and agility performance of the athlete, sports branch-specific warm-up method combined with the dynamic stretching model after static stretching can be recommended.

Keywords: speed, agility, stretching, warm-up.

Introduction

It has been widely accepted by athletes and coaches that warming-up prior to training and competition has been suggested to be critical in increasing the preparedness for subsequent effort and thus maximizing performance in the modern sporting environment (Bishop, 2003; McCrary et al., 2015; McGowan et al., 2015). It is important to realize that warm-up and stretching are two different activities. Warm-up is designed to elevate core body temperature and stretching is primarily performed to increase the range of motion at a joint or group of joints (Knudson, 2018).

While it is well accepted that generalized warm-up movements are important to maximizing sport performance and reducing injury risk in physical activity (Knudson, 2018), a pre-game warm-up for team sports typically includes a period of sub maximal running, static stretching of the major muscle groups and sport specific movements incorporating various range of motion exercises with skill-based drills executed at, or just below game intensity (Young & Behm, 2002).

There are various types of stretching such as static stretching, dynamic stretching, ballistic stretching and proprioceptive neuromuscular facilitation stretching, although numerous subtypes exist (Church et al., 2001; Funk et al., 2003; Jung et al., 2018; Peck et al., 2014; Woolstenhulme et al., 2006). Static stretching (SS) involves lengthening a muscle and moving a joint to the end of its range of motion, holding in a mildly uncomfortable stretched position for 10-60 seconds (Peck et al., 2014; Torres et al., 2008; Young & Behm, 2002). Dynamic stretching (DS), which is often used in conjunction with or in place of SS, uses momentum and active muscular effort to lengthen a muscle and involves performing movements over a full or nearly full range of motion, but the end position is not held (Behm et al., 2016; Peck et al., 2014; Thomas et al., 2018; Torres et al., 2008).

Although SS has been widely proven to be an effective method for increasing range of motion around a joint (Bandy et al., 1997; Behm et al., 2016; Power et al., 2004; Young & Behm, 2002), it has been criticized for a long time that it has a negative effect on strength, speed, agility, explosive force and jumping performance (Amiri-Khorasani et al., 2010; Behm et al., 2001; Cramer et al., 2006; Fletcher & Jones, 2004; Molacek et al., 2010; Winchester et al., 2008; Young & Behm, 2003). Accordingly, although the literature suggests that SS should be used carefully or even avoided during warm-up to prevent potentially harmful effects on muscular performance, the inclusion of SS into a pre-exercise routine prior to performance of maximal strength, power, and/or speed-related activities is thought to negatively affect the ability to perform simple and complex movements (Kay & Blazevich, 2012; Opplert & Babault, 2018).

In addition to these, DS has been become a popular choice in recent years because of the fact that DS has been demonstrated to increase performance output in strength, power, speed, agility and jumping performance (Aguilar et al., 2012; Chatzopoulos et al., 2014; Faigenbaum et al., 2005; Fletcher, 2010; Franco et al., 2012; Little & Williams, 2006). Therefore, it has been thought that the reason why the performance parameters related to SS and DS have been still different in the literature is due to differences such as the research group, training history, player level and sports branch. Studies on recreationally active individuals and tests on reactive agility parameter with different stretching protocols are seen to be limited in literature. So, in the current study, it was aimed to examine the effects of five different stretching exercise protocols on speed and agility.

Method

Participants

30 physically active male volunteers aged 23,48±1,48 years participated in the study. The inclusion criteria were determined as the absence of any health problems in the application of the tests, their volunteering during the tests and their regular participation. The exclusion criteria were determined as encountering any health problems during the study, irregularity in participation in the tests and not performing at an optimum level. All tests and training practices were performed at the same time of the day (16:00). Besides, informed consent form was obtained from each subject to involve in the study. Besides, each participant was informed about the procedure, the signed consent form was obtained and each procedure was in accordance with the Declaration of Helsinki.

Research design

All the volunteers were given detailed information about the content of the study beforehand. Necessary information was given about how to apply the tests. The height was measured by using a stadiometer (Holtain, UK) and body weight (BW) was determined in anatomical position. Body mass index (BMI) of subjects was determined by "BMI = BW (kg) / (height)^2" formula. Stretching exercises were performed under the supervision of an expert in the phases after the first warm-up (5 minutes of moderate intensity aerobic jogging). 24 hours before the tests, they were informed about not doing heavy exercise, not using alcohol, caffeine and any ergogenic aids. Each stretching exercise protocol started with 5 minutes of aerobic jogging. Volunteers performed motoric tests after the jogging was completed, except for the first warm-up application (Aydın et al., 2019). 10-20 m sprint, Illinois agility and Reactive agility tests were applied after each stretching exercise.

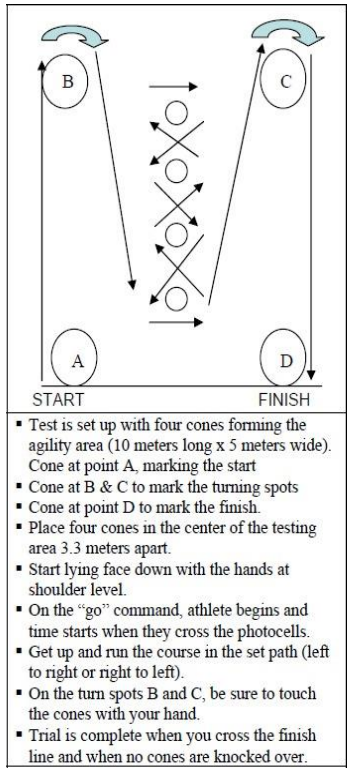
Performance tests

10-20 m sprint, Illinois agility and Reactive agility tests were used to determine the performance parameters of subjects.

Sprint Test: the subjects started the test 1 meter behind from the starting line and the speed values were recorded with the photocells placed 10 and 20 meters (Newtest 2000; Newtest Oy, Oulu, Finland). Better of two trials was recorded as "seconds".

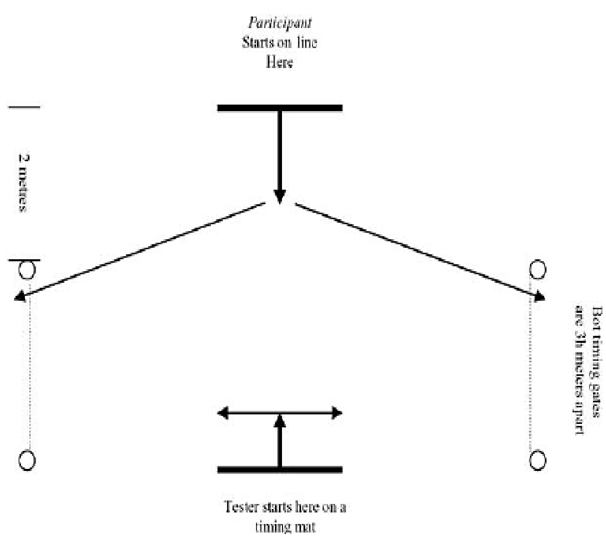
Illinois Agility Test: as seen in Figure 1, the test starts from point A and runs to point B. Afterwards, they complete the test at D point by drawing a zigzag around the funnels that are lined up 3,3 meters apart (Miller et al., 2006).

Figure 1. Illinois Agility Test (Miller et al., 2006).



Reactive Agility Test: each test trial involved the tester initiating movement, and thereby beginning the timing. The athlete reacted to the movements of the tester, forward, then to the left or right in response to, and in the same direction as, the left or right movement of the tester. The timing stopped when the athlete triggered the timing beam on either side (Sheppard et al., 2006).

Figure 2. Reactive Agility Test (Sheppard et al., 2006).



Stretching exercise protocols

Five different protocols were used in stretching exercises. These are respectively; the phase without stretching exercise, SS, DS, SS + DS and DS + SS. The phase without stretching exercise consists of 5 minutes of moderate intensity aerobic jogging; after a 5-minute jogging, without any other exercise application, performance tests of subjects were measured. In SS phase, after the necessary warm-up and the body was rested, the phase continued with eight static stretching exercises applied to the lower and upper extremities. The exercises were aimed at the latissimus dorsi (back), pectoralis major (chest), trapezius (neck), rectus abdominis (abdomen), gluteus maximus (hip), quadriceps (front of the leg), hamstring (back of the leg), gastrocnemius (calf) muscle groups. In DS phase, high glute pull, walking lung, light high knees, high knee pull, straight leg kick, carioka, skip A (jumping), B skip (jumping) were applied. Movements in both DS and SS phases were performed twice for 30 s with a 15 s rest interval between repetitions. In SS + DS phase, eight static and eight dynamic stretching exercises were applied. SS and DS exercises were applied once for 30 s and with 15 s intervals between repetitions. In DS + SS phase, eight dynamic and eight static stretching exercises were applied once for 30 s and with 15 s intervals between repetitions (Aydın et al., 2019).

Statistical analysis of data

The data were analyzed with a repeated-measures analysis of variance (ANOVA) using the SPSS 22.0 for windows statistical software. The subject attributes and investigational variables were considered as mean±SD in destructive data. Bonferroni post-hoc test was run for significance on treatment factor. Statistical significance was tested at p=0,005.

Results

Table 1. Physical statistical measurements of participants.

Variables	N	Min.	Max.	Average+S.D
Age (year)	30	21	28	23,48±1,48
Height (m)	30	1,51	1,76	1,64±0,29
BW (kg)	30	51,20	72,10	57,29±4,18
BMI (kg/m^2)	30	18,44	29,56	21,06±1,61

BW: Body Weight, BMI: Body Mass Index

The demographic values are presented in Table 1. Accordingly, the average age of the participants (n=30) was 23.48±1.48 years, mean height was 1.64±0.29 m and BW average was 57.29±4.18 kg, the mean BMI was found to be 21.06 kg/m^2.

Table 2. Comparison of the sprint performance values of the participants in terms of stretching exercise protocols.

	Protocols					
Variables	NS	SS	DS	SDS	DSS	p
10 m (s)	2,36±0,23	2,37±0,28	2,25±0,27	2,34±0,31	2,36±0,30	**0,000*** NS-DS, SS-DS, DS-SDS, DS-DSS, SDS-DSS
20 m (s)	3,93±0,22	3,90±0,23	3,76±0,30	3,85±0,30	3,87±0,29	**0,003*** NS-DS, SS-DS, DS-SDS, DS-DSS

NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDG: Static Stretching + Dynamic Stretching; DSG: Dynamic Stretching + Static Stretching.
*p< 0.05.

In table 2, when the 10 m and 20 m sprints performance parameters of groups are examined, there is statistical difference in the both parameters (p<0,05). First of all, for 10 m sprint performance test, the differences between the protocols were as follows NS with DS, SS with DS,DS with SDS, DS with DSS, SDS with DSS (p<0,05). On the other hand, looking at the 20 m sprint test results, there appears to be a statistical difference between NS with DS, SS with DS, DS with SDS, DS with DSS (p<0,05).

Table 3. Comparison of the agility performance values of the participants in terms of stretching exercise protocols.

	Protocols					
Variables	NS	SS	DS	SDS	DSS	p
Illinois Agility (s)	2,36±0,23	2,37±0,28	2,25±0,27	2,34±0,31	2,36±0,30	**0,000*** NS-DS, SS-DS, DS-SDS, DS-DSS, SDS-DSS
Reactive Agility (s)	3,93±0,22	3,90±0,23	3,76±0,30	3,85±0,30	3,87±0,29	**0,003*** NS-DS, SS-DS, DS-SDS, DS-DSS

NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDG: Static Stretching + Dynamic Stretching; DSG: Dynamic Stretching + Static Stretching.
*p< 0.05.

In Table 3, when the Illinois Agility and Reactive Agility performance parameters of groups are examined, there is a significant difference in the both features. For Illinois Agility test results there is a statistical difference between NS with DS, SS with DS, DS with SDS, DS with DSS, SDS with DSS (p<0,05). Looking at the Reactive Agility test results, there is a statistically significant between NS with DS, SS with DS, DS with SDS, DS with DSS (p<0,05).

Discussion

In the study, five different stretching modes during a pre-exercise warm-up acute effect on sprint and agility features examined. Looking at Table 1, it is seen that the average age of the participants is 23,48±1,48 years, height is 1,64±0,29 m, body weight is 57,29±4,18 kg, and BMI is 21,06±1,61 kg/m^2.

Table 2 shows that different stretching exercise protocols have a statistically significant effect on 10 m and 20 m running values ($p<0.05$). It was determined that the best results were obtained with DS and there was a significant difference in favor of DS between DS and other protocols. ($p<0.05$). In addition, it is understood that the combined stretching exercise models achieved worse results than DS but better than SS.

Looking at the literature, some researchers found that there was a decrease in sprint speed after applying static stretching between 6 sprint repetitions in their study with 12 male team athletes (Beckett et al., 2009). In a study, acute effects on 15 m running speed before jumping were investigated static and dynamic stretching exercises performed in gymnasts and as a result, it has been reported that static stretching negatively affects running speed especially in 5-10 m and 10-15 m (Siatras et al., 2003). Little & Williams (2005) found that static stretching exercises did not affect the 10 m speed and agility performance negatively in their study with 106 professional football players, and Saoulidis et al. (2010) also found that static stretching exercises did not affect the 20 m sprint performance in their study with handball players. Fletcher & Jones (2004) examined the effects of different warm-up and stretching protocols on 20 m sprint performance, including 97 rugby players, and found that static stretching applied before sprint performance decreased performance, while dynamic stretching exercise led to positive changes on 20 m sprint performance.

In a study conducted by Oliveria et al. (2018) on 12 football players, the acute effects of static, dynamic, ballistic and proprioceptive neuromuscular facilitation stretching exercises on 10-20-30 m sprint performance were investigated. As a result, it has been concluded that dynamic and ballistic stretching will have a positive effect on the use of speed. Needham et al. (2009) reported an increase in speed and jump performance tests performed after dynamic stretching exercises, while a decrease occurred after static stretching exercises. In another study, Turki et al. (2011) conducted a study with basketball, football and handball players, reported that 1-2 sets of dynamic stretching exercises performed during warm-up increased 20 m sprint performance. In addition, in this study, it was determined that combined stretching exercise protocols also caused a decrease in sprint performance compared to DS ($p<0,05$). Fletcher & Anness (2007) found that the combination of static stretching followed by dynamic stretching decreased sprint performance. Furthermore, Chaouachi et al. (2010) found that dynamic stretching followed by static stretching also decreased sprint performance. These studies support our study. According to this, it can be said that dynamic stretching exercises performed during the warm-up process have a positive effect on the speed feature but static stretching exercise model caused a fall. On the other hand, it can be thought that the combined stretching exercise types provide better sprint results than SS, although they are worse than DS.

Table 3 shows that different stretching exercise protocols have a statistically significant effect on Illinois Agility and Reactive Agility values ($p<0.05$). It was found that the best results were obtained with DS, and there was also a significant difference in favor of DS between DS and other protocols ($p<0.05$). Combined stretching exercise models, on the other hand, seem to achieve worse results than DS but better than SS. The results obtained from studies investigating the effects of stretching types on agility performance in the literature generally indicate that dynamic stretching is more suitable than static stretching in terms of agility performance (Amiri-Khorasani et al., 2010; Chatzopoulos et al., 2014; McMillian et al., 2006). Little & Williams (2006), in their study with 16 professional football players, found a significant difference in favor of the DS group from the other groups when the effect of 3 different stretching protocols applied during warm-up on the agility feature was examined. Chatzopoulos et al. (2014) applied 3 different types of stretching in their study with university students and they reported that DS agility values were the best results as a result of the study. Faigenbaum et al. (2006) reported that in their study with adolescents, the values in the group in which the DS protocol was applied were found to be significantly higher than SS.

Van Gelder & Bartz (2011) and McMillian et al. (2006) reported in their studies that the agility test results of the DS group were significantly higher than those of the SS group. Accordingly, it can be said that the information in the literature supports our study and that in order to obtain positive results in performances such as sprint and explosive strength the muscle should be at the maximum hardness level in order to produce the highest level of force. So it can be thought the dynamic stretching exercises performed during the warm-up process have a positive effect on the agility feature. On the other hand, there are studies suggesting that static stretching applications reduce speed and power performance and that static stretching should be avoided during the warm-up period (Fletcher & Anness, 2007; Hough et al., 2009; Nelson et al., 2005). In the literature, there are studies showing that static stretching can cause negative effects, as well as studies showing that this type of stretching has no effect. For example, Chaouachi et al. (2010) and Avloniti et al. (2016) state that they did not detect any difference between DS and SS groups for agility performance. Bishop & Middleton (2013) and Bradley et al. (2007) reported that static stretching caused some biomechanical changes in the tendon of the muscle. They report that this change causes the muscle to become soft and the visco-elastic properties within the muscles to change, resulting in a decrease in strength and a delay in muscle activation.

In addition, looking at the studies combining dynamic and static stretching types, Amiri-Khorasani et al. (2010) in their study, they aimed to examine the effects of static, dynamic and combination of static and dynamic stretching in pre-exercise warm-up on Illinois agility tests of 19 professional football players. As a result of the study, it is stated that the values of the dynamic stretching group are better than all other groups, also they state that the stretching method combined with dynamic stretching applied after static stretching is longer than the dynamic group but shorter than the static stretching group when looking at the agility performance after warming up. This study supports our research. Some authors state that static stretching exercises have a negative effect when applied for more than 30 seconds (Behm et al., 2004; Bradley et al., 2007; Cramer et al., 2004); on the other hand, there are authors who state that static stretching applications under 20 seconds do not have negative effects on agility performance (Avloniti et al., 2016).

When the literature is examined, although it is widely stated that static stretching applied during the warm-up process negatively affects agility, it is seen in many studies that static stretching increases flexibility (O'Sullivan et al., 2009; Samson et al., 2012). It has been reported that static stretching exercises improve flexibility; flexibility can increase athletic performance and accelerate recovery (Kisner & Colby, 2002). In addition to this information, in the literature that providing flexibility can protect athletes from injuries should not be ignored (Heyward & Gibson, 2014). When the different results between the studies are brought together, it is clearly seen that the results are affected by the differences in the stretching program and especially the applied groups, and may also depend on the different exercise levels of the subjects, the different agility tests chosen, the volume and severity of the stretches applied, and the person and muscle structure.

As a result, in line with the information obtained from the studies, it can be said that the types of stretching performed during the pre-exercise warm-up may affect the performance of the athletes. Small increases in the performance of athletes can sometimes reveal large differences that can affect the results of the competition. Therefore, it is thought that it is necessary to pay attention to the selection of stretching types to be applied in the warm-up section, taking into account the needs of the sports branch and the athlete. Dynamic stretching types should be preferred more before activities that require speed and strength. On the other hand, it is undoubtedly important to increase the flexibility of the athlete during these difficult movements and to prevent injury. For this reason, in order to increase the speed and agility performance of the athlete, sports branch-specific warm-up method combined with the dynamic stretching model after static stretching can be recommended.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Aguilar, A. J., DiStefano, L. J., Brown, C. N., Herman, D. C., Guskiewicz, K. M., & Padua, D. A. (2012). A dynamic warm-up model increases quadriceps strength and hamstring flexibility. *The Journal of Strength & Conditioning Research*, *26*(4), 1130-1141. https://doi.org/10.1519/JSC.0b013e31822e58b6

Amiri-Khorasani, M., Sahebozamani, M., Tabrizi, K. G., & Yusof, A. B. (2010). Acute effect of different stretching methods on Illinois agility test in soccer players. *The Journal of Strength & Conditioning Research*, *24*(10), 2698-2704. https://doi.org/10.1519/JSC.0b013e3181bf049c

Avloniti, A., Chatzinikolaou, A., Fatouros, I. G., Avloniti, C., Protopapa, M., Draganidis, D., ... & Kambas, A. (2016). The acute effects of static stretching on speed and agility performance depend on stretch duration and conditioning level. *The Journal of Strength & Conditioning Research*, *30*(10), 2767-2773. https://doi.org/10.1519/JSC.0000000000000568

Aydın, Y., Kafkas, A., Çınarlı, F. S., Eken, Ö., Kurt, C., & Kafkas, M. E. (2019). Farklı germe egzersizi protokollerinin bazı anaerobik motorik testler üzerine akut etkileri. *Spor Hekimliği Dergisi*, *54*(2), 99-107. https://doi.org/10.5152/tjsm.2019.121

Bandy, W. D., Irion, J. M., & Briggler, M. (1997). The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Physical Therapy*, *77*(10), 1090-1096. https://doi.org/10.1093/ptj/77.10.1090

Beckett, J. R., Schneiker, K. T., Wallman, K. E., Dawson, B. T., & Guelfi, K. J. (2009). Effects of static stretching on repeated sprint and change of direction performance. *Medicine and Science in Sports and Exercise*, *41*(2), 444-450. https://doi.org/10.1249/MSS.0b013e3181867b95

Behm, D. G., Blazevich, A. J., Kay, A. D., & McHugh, M. (2016). Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. *Applied Physiology, Nutrition, and Metabolism*, *41*(1), 1-11. https://doi.org/10.1139/apnm-2015-0235

Behm, D. G., Button, D. C., & Butt, J. C. (2001). Factors affecting force loss with prolonged stretching. *Canadian Journal of Applied Physiology*, *26*(3), 262-272. https://doi.org/10.1139/h01-017

Behm, D.G., Bambury, A., Cahill, F., & Power, K. (2004). Effect of acute static stretching on force, balance, reaction time, and movement time. *Medicine and Science in Sports and Exercise*, 36(8): 1397-1402. https://doi.org/10.1249/01.mss.0000135788.23012.5f

Bishop, D. (2003). Warm up II: performance changes following active warm up and how to structure the warm up. *Sports Medicine*, *33*(7), 483-498. https://doi.org/10.2165/00007256-200333070-00002

Bishop, D., & Middleton, G. (2013). Effects of static stretching following a dynamic warm-up on speed, agility and power. *Journal of Human Sport and Exercise*, *8*(2), 391-400. https://doi.org/10.4100/JHSE.2012.82.07

Bradley, P. S., Olsen, P. D., & Portas, M. D. (2007). The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *The Journal of Strength & Conditioning Research*, *21*(1), 223-226. https://doi.org/10.1519/00124278-200702000-00040

Brandenburg, J. P. (2006). Duration of stretch does not influence the degree of force loss following static stretching. *Journal of Sports Medicine and Physical Fitness*, *46*(4), 526-534. https://bit.ly/3FvvhpA

Chaouachi, A., Castagna, C., Chtara, M., Brughelli, M., Turki, O., Galy, O., ... & Behm, D. G. (2010). Effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals. *The Journal of Strength & Conditioning Research*, *24*(8), 2001-2011. https://doi.org/10.1519/JSC.0b013e3181aeb181

Chatzopoulos, D., Galazoulas, C., Patikas, D., & Kotzamanidis, C. (2014). Acute effects of static and dynamic stretching on balance, agility, reaction time and movement time. *Journal of Sports Science & Medicine*, *13*(2), 403-409. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3990897/pdf/jssm-13-403.pdf

Church, J. B., Wiggins, M. S., Moode, F. M., & Crist, R. (2001). Effect of warm-up and flexibility treatments on vertical jump performance. *The Journal of Strength & Conditioning Research*, *15*(3), 332-336. https://bit.ly/3W1xb6z

Cramer, J. T., Housh, T. J., Coburn, J. W., Beck, T. W., & Johnson, G. O. (2006). Acute effects of static stretching on maximal eccentric torque production in women. *The Journal of Strength & Conditioning Research*, *20*(2), 354-358. https://doi.org/10.1519/R-18105.1

Cramer, J. T., Housh, T. J., Johnson, G. O., Miller, J. M., Coburn, J. W., & Beck, T. W. (2004). Acute effects of static stretching on peak torque in women. *The Journal of Strength & Conditioning Research*, *18*(2), 236-241. https://doi.org/10.1519/R-13303.1

Faigenbaum, A. D., Bellucci, M., Bernieri, A., Bakker, B., & Hoorens, K. (2005). Acute effects of different warm-up protocols on fitness performance in children. *The Journal of Strength & Conditioning Research*, *19*(2), 376-381. https://doi.org/10.1519/R-15344.1

Faigenbaum, A. D., Kang, J., McFarland, J., Bloom, J. M., Magnatta, J., Ratamess, N. A., & Hoffman, J. R. (2006). Acute effects of different warm-up protocols on anaerobic performance in teenage athletes. *Pediatric Exercise Science*, *18*(1), 64-75. https://doi.org/10.1123/PES.18.1.64

Fletcher, I. M. (2010). The effect of different dynamic stretch velocities on jump performance. *European Journal of Applied Physiology*, *109*(3), 491-498. https://doi.org/10.1007/s00421-010-1386-x

Fletcher, I. M., & Anness, R. (2007). The acute effects of combined static and dynamic stretch protocols on fifty-meter sprint performance in track-and-field athletes. *The Journal of Strength & Conditioning Research*, *21*(3), 784-787. https://doi.org/10.1519/R-19475.1

Fletcher, I. M., & Jones, B. (2004). The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. *The Journal of Strength & Conditioning Research*, *18*(4), 885-888. https://doi.org/10.1519/14493.1

Franco, B. L., Signorelli, G. R., Trajano, G. S., Costa, P. B., & de Oliveira, C. G. (2012). Acute effects of three different stretching protocols on the Wingate test performance. *Journal of Sports Science & Medicine*, *11*(1), 1-7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3737835/pdf/jssm-11-1.pdf

Funk, D. C., Swank, A. M., Mikla, B. M., Fagan, T. A., & Farr, B. K. (2003). Impact of prior exercise on hamstring flexibility: a comparison of proprioceptive neuromuscular facilitation and static stretching. *The Journal of Strength & Conditioning Research*, *17*(3), 489-492. https://doi.org/10.1519/1533-4287(2003)017<0489:iopeoh>2.0.co;2

Heyward, V.H., & Gibson, A.L. (2014). *Advanced fitness assessment and exercise prescription.* Human Kinetics.

Hough, P. A., Ross, E. Z., & Howatson, G. (2009). Effects of dynamic and static stretching on vertical jump performance and electromyographic activity. *The Journal of Strength & Conditioning Research*, *23*(2), 507-512. https://doi.org/10.1519/JSC.0b013e31818cc65d

Jung, H. C., Lee, N. H., & Lee, S. (2018). Jumping exercise restores stretching-induced power loss in healthy adults. *Montenegrin Journal of Sports Science and Medicine*, *7*(2), 55-62. https://doi.org/10.26773/mjssm.180909

Kay, A. D., & Blazevich, A. J. (2012). Effect of acute static stretch on maximal muscle performance: a systematic review. *Medicine & Science in Sports & Exercise*, *44*(1), 154-164. https://doi.org/10.1249/MSS.0b013e318225cb27

Kisner, C., & Colby, C.A. (2002). *Therapeutic exercise: foundations and techniques*. F. A. Davis.

Knudson, D. V. (2018). Warm-up and Flexibility. In T. J. Chandler & L. E. Brown (Eds.), *Conditioning for strength and human performance* (pp. 212-231). Routledge.

Little, T., & Williams, A. G. (2006). Effects of differential stretching protocols during warm-ups on high speed motor capacities in professional soccer players. *The Journal of Strength & Conditioning Research*, *20*(1), 203-207. https://doi.org/10.1519/R-16944.1

Little, T., & Williams, A.G. (2005). Specificity of acceleration, maximum speed and agility in professional soccer players. *The Journal of Strength & Conditioning Research*, *19(*1), 76-78. https://doi.org/10.1519/14253.1

McCrary, J. M., Ackermann, B. J., & Halaki, M. (2015). A systematic review of the effects of upper body warm-up on performance and injury. *British Journal of Sports Medicine*, *49*(14), 935-942. https://doi.org/10.1136/bjsports-2014-094228

McGowan, C. J., Pyne, D. B., Thompson, K. G., & Rattray, B. (2015). Warm-up strategies for sport and exercise: mechanisms and applications. *Sports Medicine*, *45*(11), 1523-1546. https://doi.org/10.1007/s40279-015-0376-x

McMillian, D. J., Moore, J. H., Hatler, B. S., & Taylor, D. C. (2006). Dynamic vs. static-stretching warm up: the effect on power and agility performance. *The Journal of Strength & Conditioning Research*, *20*(3), 492-499. https://doi.org/10.1519/18205.1

Miller, M. G., Herniman, J. J., Ricard, M. D., Cheatham, C. C., & Michael, T. J. (2006). The effects of a 6-week plyometric training program on agility. *Journal of Sports Science & Medicine*, *5*(3), 459-465. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3842147/pdf/jssm-05-459.pdf

Molacek, Z. D., Conley, D. S., Evetovich, T. K., & Hinnerichs, K. R. (2010). Effects of low-and high-volume stretching on bench press performance in collegiate football players. *The Journal of Strength & Conditioning Research*, *24*(3), 711-716. https://doi.org/10.1519/JSC.0b013e3181c7c242

Needham, R. A., Morse, C. I., & Degens, H. (2009). The acute effect of different warm-up protocols on anaerobic performance in elite youth soccer players. *The Journal of Strength & Conditioning Research*, *23*(9), 2614-2620. https://doi.org/10.1519/JSC.0b013e3181b1f3ef

Nelson, A. G., Driscoll, N. M., Landin, D. K., Young, M. A., & Schexnayder, I. C. (2005). Acute effects of passive muscle stretching on sprint performance. *Journal of Sports Sciences*, *23*(5), 449-454. https://doi.org/10.1080/02640410410001730205

Oliveira, L. P., Vieira, L. H., Aquino, R., Manechini, J. P., Santiago, P. R., & Puggina, E. F. (2018). Acute effects of active, ballistic, passive, and proprioceptive neuromuscular facilitation stretching on sprint and vertical jump performance in trained young soccer players. *The Journal of Strength & Conditioning Research*, *32*(8), 2199-2208. https://doi.org/10.1519/JSC.0000000000002298

Opplert, J., & Babault, N. (2018). Acute effects of dynamic stretching on muscle flexibility and performance: an analysis of the current literature. *Sports Medicine*, *48*(2), 299-325. https://doi.org/10.1007/s40279-017-0797-9

O'Sullivan, K., Murray, E., & Sainsbury, D. (2009). The effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. *BMC Musculoskeletal Disorders*, *10*(1), 1-9. https://doi.org/10.1186/1471-2474-10-37

Peck, E., Chomko, G., Gaz, D. V., & Farrell, A. M. (2014). The effects of stretching on performance. *Current Sports Medicine Reports*, *13*(3), 179-185. https://doi.org/10.1249/JSR.0000000000000052

Power, K., Behm, D., Cahill, F., Carroll, M., & Young, W. (2004). An acute bout of static stretching: effects on force and jumping performance. *Medicine and Science in Sports and Exercise*, *36*, 1389-1396. https://doi.org/10.1249/01.mss.0000135775.51937.53

Samson, M., Button, D. C., Chaouachi, A., & Behm, D. G. (2012). Effects of dynamic and static stretching within general and activity specific warm-up protocols. *Journal of Sports Science & Medicine*, *11*(2), 279-285. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3737866/pdf/jssm-11-279.pdf

Saoulidis, J., Yiannakos, A., Galazoulas, C. H., Zaggelidis, G., & Armatas, V. (2010). Acute effect of short passive and dynamic stretching on 20m sprint performance in handball players. *Physical Training*, *11*, 6-10. http://ikee.lib.auth.gr/record/230821/files/AcuteEffect.pdf

Sheppard, J. M., Young, W. B., Doyle, T. L. A., Sheppard, T. A., & Newton, R. U. (2006). An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. *Journal of Science and Medicine in Sport*, *9*(4), 342-349. https://doi.org/10.1016/j.jsams.2006.05.019

Siatras, T., Papadopoulos, G., Mameletzi, D., Gerodimos, V., & Kellis, S. (2003). Static and dynamic acute stretching effect on gymnasts' speed in vaulting. *Pediatric Exercise Science*, *15*(4), 383-391. https://doi.org/10.1123/pes.15.4.383

Thomas, E., Bianco, A., Paoli, A., & Palma, A. (2018). The relation between stretching typology and stretching duration: the effects on range of motion. *International Journal of Sports Medicine*, *39*(04), 243-254. https://doi.org/10.1055/s-0044-101146

Torres, E. M., Kraemer, W. J., Vingren, J. L., Volek, J. S., Hatfield, D. L., Spiering, B. A., ... & Maresh, C. M. (2008). Effects of stretching on upper-body muscular performance. *The Journal of Strength & Conditioning Research*, *22*(4), 1279-1285. https://doi.org/10.1519/JSC.0b013e31816eb501

Turki, O., Chaouachi, A., Drinkwater, E. J., Chtara, M., Chamari, K., Amri, M., & Behm, D. G. (2011). Ten minutes of dynamic stretching is sufficient to potentiate vertical jump performance characteristics. *The Journal of Strength & Conditioning Research*, *25*(9), 2453-2463. https://doi.org/10.1519/JSC.0b013e31822a5a79

Van Gelder, L. H., & Bartz, S. D. (2011). The effect of acute stretching on agility performance. *The Journal of Strength & Conditioning Research*, *25*(11), 3014-3021. https://doi.org/10.1519/JSC.0b013e318212e42b

Winchester, J. B., Nelson, A. G., Landin, D., Young, M. A., & Schexnayder, I. C. (2008). Static stretching impairs sprint performance in collegiate track and field athletes. *The Journal of Strength & Conditioning Research*, *22*(1), 13-19. https://doi.org/10.1519/JSC.0b013e31815ef202

Woolstenhulme, M. T., Griffiths, C. M., Woolstenhulme, E. M., & Parcell, A. C. (2006). Ballistic stretching increases flexibility and acute vertical jump height when combined with basketball activity. *The Journal of Strength & Conditioning Research*, *20*(4), 799-803. https://doi.org/10.1519/R-18835.1

Young W & Behm, D. (2002). Should static stretching be used during a warm-up for strength and power activities? *Strength and Conditioning Journal,* 24(6), 33-37. https://doi.org/10.1519/00126548-200212000-00006

Young, W. B., & Behm, D. G. (2003). Effects of running, static stretching and practice jumps on explosive force production and jumping performance. *Journal of Sports Medicine and Physical Fitness*, *43*(1), 21-27. https://bit.ly/3usYwmJ

Information about the authors

Ali Erdem Cigerci
Associate Professor, Doctor. Kastamonu University, Faculty of Sports Sciences. Turkey.
Corresponding author: aecigerci@kastamonu.edu.tr

Harun Genc
Associate Professor, Doctor. Bingol University, Faculty of Sports Sciences. Turkey.

Veli Volkan Gurses
Associate Professor, Doctor. Kastamonu University, Faculty of Sports Sciences. Turkey.

Ozan Sever
Associate Professor, Doctor. Ataturk University, Faculty of Sports Sciences. Turkey.

Ozcan Kızılbag
Kastamonu University, Instıtute of Health Sciences. Turkey.