Journal of Human Kinetics volume 50/2016, 179-186 DOI: 10.1515/hukin-2015-0154
Section III – Sports Training

Acute Effect of Different Combined Stretching Methods on Acceleration and Speed in Soccer Players

by
Mohammadtaghi Amiri-Khorasani[1], *Julio Calleja-Gonzalez*[2],
Mansooreh Mogharabi-Manzari[3]

The purpose of this study was to investigate the acute effect of different stretching methods, during a warm-up, on the acceleration and speed of soccer players. The acceleration performance of 20 collegiate soccer players (body height: 177.25 ± 5.31 cm; body mass: 65.10 ± 5.62 kg; age: 16.85 ± 0.87 years; BMI: 20.70 ± 5.54; experience: 8.46 ± 1.49 years) was evaluated after different warm-up procedures, using 10 and 20 m tests. Subjects performed five types of a warm-up: static, dynamic, combined static + dynamic, combined dynamic + static, and no-stretching. Subjects were divided into five groups. Each group performed five different warm-up protocols in five non-consecutive days. The warm-up protocol used for each group was randomly assigned. The protocols consisted of 4 min jogging, a 1 min stretching program (except for the no-stretching protocol), and 2 min rest periods, followed by the 10 and 20 m sprint test, on the same day. The current findings showed significant differences in the 10 and 20 m tests after dynamic stretching compared with static, combined, and no-stretching protocols. There were also significant differences between the combined stretching compared with static and no-stretching protocols. We concluded that soccer players performed better with respect to acceleration and speed, after dynamic and combined stretching, as they were able to produce more force for a faster execution.

Key words: *combined stretching, soccer, acceleration, speed, warm-up.*

Introduction

Preparation for performances such as jumping, acceleration, speed, agility, and others, should involve both long and short-term training programs. Long-term preparation may include a well-developed fitness training program, whereas short-term preparation should include a warm-up (Amiri-Khorasani et al., 2010). One part of a warm-up includes stretching, which is often performed prior to physical exercises (Amiri-Khorasani et al., 2010, 2011). There are various stretching techniques, including static (SS), ballistic, proprioceptive neuromuscular facilitation (PNF), and dynamic stretching (DS) (Amiri-Khorasani et al., 2010; Behm et al., 2001). Typically, stretching is used to enhance the range of motion (ROM) of a joint (Amiri-Khorasani, 2013; Amiri-Khorasani et al., 2011). Since FIFA developed and evaluated its injury prevention programs, "The 11" and "FIFA 11+", it has been demonstrated in several scientific studies how simple exercise-based programs can decrease the incidence of injuries in amateur soccer players (Bizzini et al., 2013).

In soccer, SS among different methods is

[1] - *Department of Sports Biomechanics, Faculty of Physical Education and Sports Science, Shahid Bahonar University of Kerman, Kerman, Iran.*
[2] - *Faculty of Physical Activity and Sport Sciences, University of the Basque Country, Spain.*
[3] - *Faculty of Physical Education and Sports Science, University of Gilan, Iran.*

Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 50/2016 in March2016.

often performed before exercise and athletic performance as it is widely believed that pre-exercise SS decreases injury risk and improves performance (Eventovich et al., 2003). However, recent studies have showed that SS reduces muscular performance (Curry et al., 2009; Faigenbaumm et al., 2005; Behm et al., 2001; Church et al., 2001; Nelson et al., 2001), whereas other studies have reported that DS improves performance compared with SS (Herda et al., 2008; Little and Williams, 2006; Mcmillian and Moore, 2003). Many researchers have reported that DS should replace SS because of an SS-induced decrease in performance. Although they have demonstrated positive effects of DS, they suggested players should perform SS and DS together, for a better adaptation. Although previous studies (Amiri-Khorasani and Sotoodeh, 2013; Amiri-Khorasani et al., 2010; Faigenbaumm et al., 2005; Mikolajec et al., 2012) have investigated the combined effects of SS and DS on power, agility, and speed; however, the results were unclear about the effect of the order within each stretching combinations on fitness performances.

To this date, no research has investigated the effect of order of stretching combinations on the acceleration and speed of soccer players, even though soccer is the most popular team sport worldwide. In this way, there is an open practical question: during a warm-up, which order of stretching combination, SS + DS or DS + SS, increases acceleration and speed in soccer players? Therefore, the purpose of this study was to address this question, investigating the effect of SS, DS, combination of SS and DS (CSD), and combination of DS and SS (CDS) on acceleration and speed in soccer players.

Material and Methods

Participants

Twenty soccer players (body height: 177.25 ± 5.31cm; body mass: 65.10 ± 5.62 kg; age: 16.85 ± 0.87 years; BMI: 20.70 ± 5.54; training experience: 8.46 ± 1.49 years) were evaluated during their athletic training program, in the middle of the 2012-2013 season. According to the inclusion criteria of the study, all subjects belonged to a first soccer division, played in the official games of the season and were not injured during the six months preceding the study. Our selection of highly trained and motivated soccer players was based on our experience that competitive athletes were generally willing and able to withstand considerable discomfort. They performed regular endurance, strength, sprint, and soccer specific training from 3 to 6 days per week, for more than 8 years. All participants were properly informed of the experimental risks and the nature of the study, without being informed of its detailed objectives. Prior to testing, an informed consent form was signed by all subjects and their parents in accordance with the Declaration of Helsinki (Seoul, 2008). The study was approved beforehand by the Shahid Bahonar University institutional review board.

Procedure

The anthropometric variables including body height (cm) and body mass (kg) of each subject were measured. Body height was measured to the nearest 0.1 cm with precision of ±2 mm, and a range of 130–210 cm. Body mass was obtained to the nearest 0.1 kg. The BMI was calculated using the following formula: BMI = body mass (kg) × height (m)$^{-2}$.

The current research protocol was adapted from Taylor et al. (2012), Amiri-Khorasani et al. (2010), and Little and Williams (2006). Subjects were divided into five groups, as illustrated in Table 1. The randomization of treatment order for each subject and the division of all subjects into five different groups aimed to control possible bias, such as effects of testing or interactions, weather, the pitch, time, and others. Each group performed five different warm-up protocols in five non-consecutive days (Table 1). The warm-up protocol used for each group was randomly assigned. Subjects performed 4 min jogging, a 1 min stretching program (except for no stretching protocol), and rested for 2 min. Following the warm-up, the participants performed the 10 m and 20 m tests. All sessions were conducted at the same time in the evenings (the participants' regular training session time) and at same adequate temperature and humidity ranges (28°C–32°C and 34%, respectively). Prior to data collection, all subjects attended an introductory session. During this session, duration time of data collection, technique of each warm-up protocol and the fitness test were reviewed and practiced.

The SS was conducted on the main lower extremity muscle groups: gastrocnemius, hamstrings, quadriceps, hip flexors, hip extensors and adductors (Amiri-Khorasani et al., 2010; Little and Williams, 2006), as described in Table 2. For each muscle group, subjects held the SS for 30 s on one leg, before changing to the contralateral side. Subjects were previously instructed to stretch in a slow, deliberate manner with proper body alignment.

The procedures for performing DS on the same muscle groups, stretched in the SS protocol, were adopted from Amiri-Khorasani et al. (2010), and Little and Williams (2006). As explained in Table 3, subjects were instructed to aim for maximal ROM during each repetition. In a standing position, each subject intentionally contracted the target muscle antagonist once every second, stretching the target muscle. This stretching was performed five times, without any bouncing, for each different speed protocol (slow, moderate, and as-fast-as-possible, in this order). The order of target muscles and rest periods was the same as in SS.

In the CSD protocol, subjects performed the same movements, therefore stretching the same muscles, as in the SS and DS protocols, however, they first performed the SS protocol and then the DS protocol (Amiri-Khorasani and Sotoodeh, 2013; Amiri-Khorasani et al., 2010). In the CDS protocol, the order was inverted. In the NS protocol, instead of stretching, the subjects rested for 2 min after the general warm-up.

Acceleration and speed were evaluated using the stationary 10 m sprint and the flying 20 m sprint, respectively, as in Amiri-Khorasani and Sotoodeh (2013), Little and Williams (2006) and Faigenbumm et al. (2005). The subjects were positioned 0.5 m from the starting point and began the tests when they felt ready (Castagna et al., 2011). Time was recorded using ± 0.001 s accuracy photocell gates (MTAK16, KER, IR) placed 0.4 m above the ground (Gorostiaga et al., 2004). The timer was automatically activated as the subjects passed the first gate at the 0.0 m mark, and split times were recorded at 10 m. This testing design was also conducted for the flying 20 m sprint, with the difference that split times were recorded at 20 m. The best score of three trials was recorded for each fitness test (Little and Williams, 2006; Faigenbumm et al., 2005). All sessions were performed with identical equipment, positioning, technique, test order (a stationary 10 m sprint and a flying 20 m sprint) and the same personnel. All subjects rested for at least 3 min between tests, and completed the fitness test battery in about 5–10 min. Testing procedures used in this study were designed to be similar to fitness testing procedures used in most soccer conditioning programs.

Statistical Analysis

To allow an easier comparison, all data from the SS, DS, CSD, and CDS trials were normalized to NS data. Therefore, values were calculated as relative acceleration and relative speed. Data are presented as average ± standard deviation.

The distribution of each variable was examined with Shapiro-Wilk ($n < 50$) normality tests. Homogeneity of variance was verified by a Levene test, and sphericity was verified by a Mauchly test. All variables were analyzed with parametric tests. The effect of different stretching methods on acceleration and speed was determined using one-way repeated-measures analysis of variance (ANOVA). When justified, paired t-tests were performed to confirm significant changes within each condition. The post-hoc Bonferroni adjustment was then carried out to confirm the significant differences. A significance level of $p \le 0.05$ was accepted. Statistical analyses were carried out using SPSS v 20.0 (Chicago, Illinois, USA).

Results

The results showed a faster acceleration after DS (−0.01 ± 0.02) than after SS (0.002 ± 0.02) ($p < 0.053$) and CSD (−0.007 ± 0.02) vs. SS (0.002 ± 0.02) ($p < 0.043$) (Figure 1). There were no significant differences between DS (−0.01 ± 0.02) vs. CSD (−0.007 ± 0.02), DS (−0.01 ± 0.02) vs. CDS (−0.002 ± 0.02), SS (0.002 ± 0.02 s) vs. CDS (−0.002 ± 0.02), and CSD (−0.007 ± 0.02) vs. CDS (−0.002 ± 0.02), as illustrated in Figure 1.

In addition, present findings showed a faster speed after DS (−0.008 ± 0.05 s) than after SS (0.01 ± 0.06 s) ($p < 0.037$) and CSD (−0.006 ± 0.06 s) vs. SS (0.01 ± 0.06 s) ($p < 0.095$) (Figure 1). There were no significant differences between DS (−0.008 ± 0.05 s) vs. CSD (−0.006 ± 0.06 s), DS (−0.008 ± 0.05 s) vs. CDS (−0.002 ± 0.06 s), SS (0.01 ± 0.06 s) vs. CDS (−0.002 ± 0.06 s), and CSD (−0.006 ± 0.06 s) vs. CDS (−0.002 ± 0.02 s), as shown in Figure 2.

Table 1

Testing schedule for soccer players

	Groups	1	2	3	4	5
First day	4 min jogging	+	+	+	+	+
	Stretching protocol	No	S	D	CSD	CDS
	2 min jogging	+	+	+	+	+
	Fitness test	+	+	+	+	+
Second day	4 min jogging	+	+	+	+	+
	Stretching protocol	CDS	No	S	D	CSD
	2 min jogging	+	+	+	+	+
	Fitness test	+	+	+	+	+
Third day	4 min jogging	+	+	+	+	+
	Stretching protocol	CSD	CDS	No	S	D
	2 min jogging	+	+	+	+	+
	Fitness test	+	+	+	+	+
Fourth day	4 min jogging	+	+	+	+	+
	Stretching protocol	D	CSD	CDS	No	S
	2 min jogging	+	+	+	+	+
	Fitness test	+	+	+	+	+
Fifth day	4 min jogging	+	+	+	+	+
	Stretching protocol	S	D	CSD	CDS	No
	2 min jogging	+	+	+	+	+
	Fitness test	+	+	+	+	+

(+) denotes activity included; (s) Static; (D) Dynamic; (CSD) Combined (Static + Dynamic); (CDS) Combined (Dynamic + Static)

Table 2

Different static stretching protocols for lower limb muscles

Muscles	**Description**
Gastrocnemius	From a push-up position, the subject moved his hands closer to his feet to raise his hips and form a triangle. At the highest point of the triangle, the subject slowly pressed his heels against the floor, or alternated slowly flexing one knee while keeping the opposite leg extended.
Hamstrings	The subject sat on the floor with both legs extended in front of the body, back straight, and flexed at the hips, before reaching to touch the feet with the hands.
Hip extensors	The subject flexed the hip, by raising the knee toward the chest with the assistance of the force applied by the hands, which were interlocked behind the raised knee. Hip flexion was synchronized with inhalation.
Hip flexors	The subject stood upright with the legs spread apart and the hands on the hips (or one hand on the front knee), and during exhalation flexed the front knee to a 90-degree angle while keeping the rear knee extended.
Quadriceps	The subject slightly flexed the supporting leg, exhaled, and grasped the raised foot with one hand before pulling the heel towards the buttocks during inhalation.
Hip Adductors	The subject sat on the floor with knees flexed so that the feet touched before placing the elbows on the inner thighs and pushing the legs towards the floor during exhalation

Table 3
Different dynamic stretching methods for lower limb muscles

Muscles	Description
Gastrocnemius	First, the subject raised one foot from the floor and fully extended the knee. Then, he intentionally contracted the dorsiflexors to point the foot upwards.
Hamstrings	From a standing position with both legs straight, the subject contracted the hip flexors to swing the leg forward.
Hip extensors	The subject intentionally contracted the hip flexors with the knees flexed to bring the thigh to the chest.
Hip flexors	From a comfortable standing position, the subject contracted the hip extensors to swing the leg backwards.
Quadriceps	The subject contracted the hamstrings to flex the leg so that the heel touched the buttocks.
Hip Adductors	The subject intentionally contracted the hip abductors with the knee extended to swing the leg laterally.

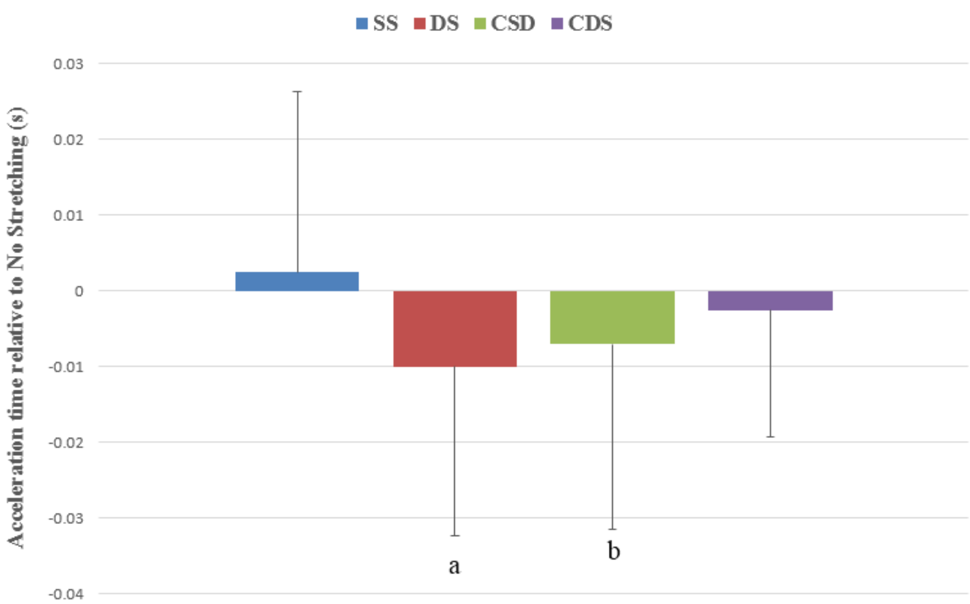

Figure 1
Acceleration time after static (SS), dynamic (DS), static + dynamic (CSD), and dynamic + static (CDS) relative to no stretching in soccer players. (a) Significantly faster time after DS versus SS relative to no stretching. (b) Significantly faster time after CSD versus SS relative to no stretching.

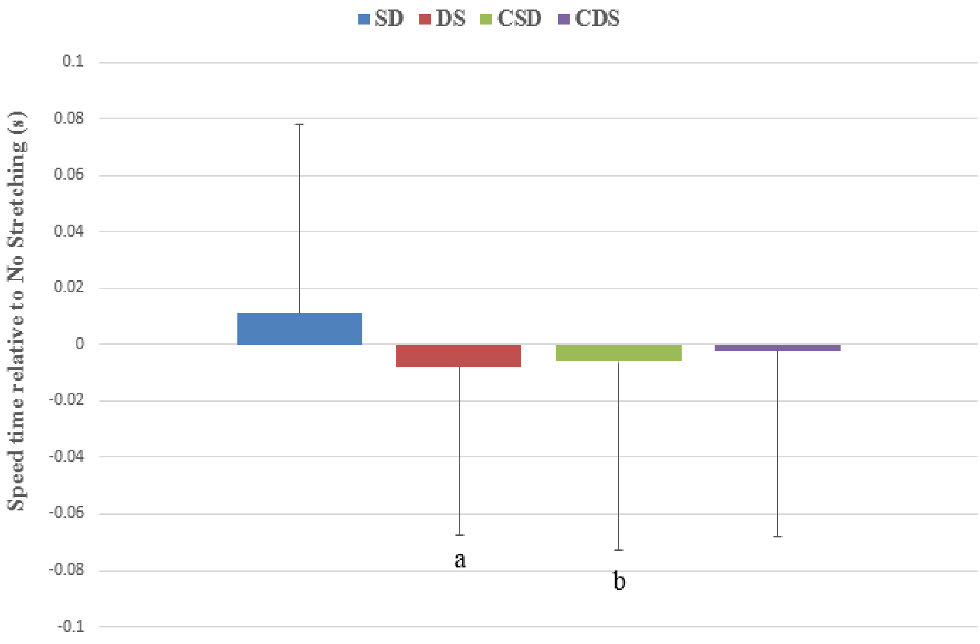

Figure 2

Speed time after static (SS), dynamic (DS), static + dynamic (CSD), and dynamic + static (CDS) relative to no stretching in soccer players. (a) Significantly faster time after DS versus SS relative to no stretching. (b) Significantly faster time after CSD versus SS relative to no stretching.

Discussion

To our knowledge, this is the first study to examine the acute effects of NS, SS, DS, CSD, and CDS protocols on the acceleration and speed of soccer players. Present findings showed significant differences in acceleration and speed after DS, compared with those after SS (Figures 1 and 2). These findings are similar to previous studies (Amiri-Khorasani et al., 2010; Little and Williams, 2006; Faigenbumm et al., 2005). On the other hand, there were no significant differences between the other protocols; however, the results showed a faster mean score for DS, CSD, CDS, and finally SS.

Regarding the SS-induced performance decrease, two hypothetical reasons were suggested: (a) mechanical factors involving the muscle viscoelastic properties that may affect the muscle's length–tension relationship, and (b) neural factors such as decreased muscle activation or altered reflex sensitivity (Cramer et al., 2005; Unick and Kieffer, 2005; Cornwell al., 2002). In addition, two hypotheses were suggested to explain the positive effect of DS: (a) some level of post-activation potentiation (PAP), and (b) increased muscle temperature. Faster sprint times observed after DS than after NS and SS may be related to PAP as well as the lack of stretch-induced deficits (Amiri-Khorasani et al., 2011; Herda et al., 2008; MacMilliam and Moore, 2003).

According to the current findings, it seemed that DS, through PAP and optimal muscle temperature, caused a better force production, which in turn caused a faster acceleration and speed. In contrast, it could be stated that due to less muscle stiffness and decreased muscle activation, acceleration and speed decreased after SS. It seemed that in CSD, the DS section increased the lower extremity muscles PAP and compensated the SS effects. This resulted in a higher force production than that by performing only SS. In addition, performances were faster after CDS than after SS although there was no significant difference between these two protocols. It was observed that any stretching protocol, followed by DS, increased acceleration and speed. Therefore, the findings suggested that DS resulted in faster performances owing to higher PAP and an optimal muscle temperature increase.

Acute effects of stretching are not as significant for sport performance as chronic changes that occur after several weeks of particular stretching protocols. This causes specific adaptive changes in the muscular tendon structure and influences the neurophysiological properties of these tissues. It should be mentioned that the acute effect as compared to chronic effect was a limitation of this study. Therefore, authors suggest investigating the chronic effect of stretching on fitness performance in soccer players.

Conclusion

The current findings show that DS during a warm-up is more effective than SS as a preparation to the abrupt acceleration and speed required in soccer. Our results suggest that if soccer players are still interested in performing SS, they should follow a combined stretching protocol, having in mind that CSD is better than CDS. Future studies should investigate these differences among players with respect to different plying positions and at different times of the season. Thus, we suggest to coaches, trainers, fitness coaches, and physical educators to use DS or CSD, instead of SS and CDS during a warm-up in soccer players.

Acknowledgements

The authors would like to thank football players for their kind participation and coaches for the opportunity to investigate.

References

Amiri-Khorasani M. Kinematics Analysis: The Acute Effect of Different Stretching Methods on Dynamic Range of Motion of Lower Extremity Joints during Soccer Instep Kicking. *International J Performance Analysis Sport*, 2013; 13(1): 190-199

Amiri-Khorasani M, Sahebozamani M, Tabrizi KG, Yusof A. Acute effect of different stretching methods on Illinois agility test in soccer players. *J Strength Cond Res,* 2010; 24(10): 2698-2704

Amiri-Khorasani M, Osman NA, Ashril Y. Acute Effect of Static and Dynamic Stretching on Hip Dynamic Range of Motion (DROM) during Instep Kicking in Professional Soccer Players *J Strength Cond Res,* 2011; 25(4): 1177-1181

Amiri-Khorasani M, Sotoodeh V. The acute effects of combined static and dynamic stretch protocols on fitness performances in soccer players. *J Sports Med Phys Fitness*, 2013; 53(5): 559-565

Behm DG, Button DC, Butt J. Factors affecting force loss with prolonged stretching. *Canadian J Appl Physio*, 2001; 26: 261-272

Bizzini M, Junge A, Dvorak J. Implementation of the FIFA 11+ football warm up program: How to approach and convince the Football associations to invest in prevention. *J Sports Med*, 2013; 47(12): 803-806

Castagna C, Impellizzeri FM, Bizzini M, Weston M, Manzi V. Applicability of a change of direction ability field test in soccer assistant referees. *J Strength Cond Res*, 2011; 25(3): 860-866

Cornwell A, Nelson AG, Sidaway B. Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. *European J Appl Physio,* 2002; 86: 428-434

Cramer JT, Housh TJ, Johnson GO, Miller JM, Coburn JW, Beck TW. The acute effects of static stretching on peak torque, mean power output, electromyography, and mechanomyography. *European J Appl Physio,* 2005; 93: 530-539

Church JB, Wiggins MS, Moode FM, Crist R. Effect of warm-up and flexibility treatments on vertical jump performance. *J Strength Cond Res,* 2001; 15: 332-336

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

Eventovich TK, Nauman NJ, Conley DS, Todd JB. Effect of static stretching of the biceps brachii on torque, electromyography, mechanomyography during concentric isokinetic muscle actions. *J Strength Cond Res,* 2003; 17: 484-488

Faigenbaum A, Bellucci M. Bernieri A. Bakker B. Hoorens K. Acute effects of different warm-up protocols on fitness performance in children. *J Strength Cond Res,* 2005; 19: 376–381

Gorostiaga EM, Izquierdo M, Ruesta M, Iribarren J, González-Badillo JJ, Ibáñez J. Strength training effects on physical performance and serum hormones in young soccer players. *European J Applied Physi,* 2004; 91(5-6): 698-707

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

Little T, Williams G. Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J Strength Cond Res,* 2006; 20(1): 203-207

Mcmillian DJ, Moore JH. Dynamic vs. static-stretching warm up: The effect on power and agility performance. *J Strength Cond Res,* 2003; 20(3): 492-499

Mikolajec K, Waskiewicz Z, Maszczyk A, Bacik B, Kurek P, Zając A. Effects of stretching and strength exercises on speed and power abilities in male basketball players. *Isokinetics and Exercise Science,* 2012; 20: 61–69

Nelson AG, Allen JD, Cornwell A, Kokkonen J. Inhibition of maximal voluntary isometric torque production by acute stretching is joint-angle specific. *Res Quarterly Exerc Sport,* 2001; 72: 68-70

Taylor J, Weston M, Portas MD. The effect of a short, practical warm-up protocol on repeated-sprint performance. *J Strength Cond Res,* 2013; 27(7): 2034-8

Unick J, Kieffer HS. The acute effects of static and ballistic stretching on vertical jump performance in trained women. *J Strength Cond Res,* 2005; 19(1): 206-212

Corresponding author:

Dr. Mohammadtaghi Amiri-Khorasani
Address: Faculty of Physical Education and Sports Science, University of Shahid Bahonar, Kerman, Iran
Phone.: 00989131999143
Fax.: 00983412812777
Email: amirikhorasani@uk.ac.ir