Acute effect of static and dynamic stretching exercise on sprint and flexibility of amateur soccer players

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Abstract

The main aim of the study was to examine the acute effects of static and dynamic stretching during warm-up on the sprinting speed of amateur soccer players. The secondary aim was to determine the acute effect of stretching on the lower extremities flexibility. Eighteen adult athletes participated in the study, randomly performing 3 distinct flexibility protocols on non-consecutive training sessions. The first protocol comprised of 10min of soccer warm-up exercises, flexibility and sprint assessment, followed by 5min of static stretching and sprints. The second protocol was akin to the first one, except for the static stretching exercises, which were substituted for calisthenics, performed in a limited range of motion (ROM). The third protocol was similar to the second, but calisthenics were performed in a full ROM. Stretches were held for 10’’ and were repeated once more. Passive ROM was measured during hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion in the right side of the body, with the use of a flexometer. The duration of the sprint was measured with photocells. Statistical analysis revealed that the static stretching protocol significantly reduced the sprint speed of soccer players ($p<0.01$) whereas the two dynamic protocols significantly improved sprint speed of participants ($p<0.05$ to $p<0.01$). On the other hand, static stretching and calisthenics, performed in a full ROM induced significant increases ($p<0.001$) in lower extremities joint flexibility of soccer players, whereas calisthenics exercises performed in limited ROM induced a significant increase ($p<0.05$) only on the knee dorsiflexion. The findings indicate that the type of stretching performed prior to exercise, affects sprint capacity and lower extremity flexibility.

Key words: *Soccer general warm-up; static stretching; calisthenics; sprint; amateur soccer players*

Introduction

Soccer consists of the most popular sport in the world (FIFA, 2012), involving a plethora of different motor actions performed during match play, all at various intensities. These movements require good joint flexibility –or normal range of motion (ROM)- as well as increased power and strength, such as sudden starts, stops, jumps, duels, feints and sprints (Carling et al., 2010; Reilly and Thomas, 1976).

The most common techniques for improving flexibility in soccer are static/passive techniques and the active/dynamic technique of stretching. Static stretching is typically performed in a slow pace until the final joint positioning is reached, or alternatively, at the full ROM of the joint, which the athlete attains for few seconds (van Gyn, 1986). Dynamic stretching comprises of classic gymnastics exercises, performed by the athlete alone or with the help of the trainer, stretching through the full joint ROM. These movements can be performed either at a slow rhythmical pace, or at a dynamic repetitive pace (e.g. swinging, bouncing, etc.) (Moore and Hutton, 1980).

It is common for athletes and in particular soccer players, to perform static stretching exercises after mild-intensity aerobic sessions, as part of their pre-exercise warm-up routine (Young and Behm, 2003). This is due to the belief that static stretching is considered safe and easy to perform (Yamaguchi and Ishii, 2005), is associated with a reduced injury risk (Sady et al., 1982), deemed effective in increasing ROM (Smith, 1994), improving performance (Shellock and Prentice, 1985) and decreasing muscle soreness (High et al., 1989). Additional findings stress the effect of static stretching exercises to reduce/prevent injury risk as a result of tight musculature (Safran et al., 1989; Smith 1994; Jonhages et al., 1994), although Shrier (1999) aptly suggested that increased flexibility does not necessarily confer injury protection.

For decades, static stretching has been an integral part of warm-up sessions in both training and competition, in an attempt to increase flexibility, sports performance and injury prevention, however, recent data suggest a decrease in athletic performance post-static stretching (Nelson et al., 2001; Young and Elliott, 2001; Behm et al., 2001; Cornwell et al., 2001; Chaouachi et al., 2008; Gelen, 2010). In particular, the research groups of Nelson and Behm and their associates (2001) both demonstrated a reduction in muscle strength, Cornwell and his colleagues (2001) postulated a decrease in power production of the involved muscle groups, whereas more recently, other scientists (Chaouachiet al., 2008; Gelen, 2010) exhibited a reduction in sprint speed.

Nowadays, increased flexibility is more frequently attained with dynamic-type muscle elongation exercises incorporated in warm-up sessions, as research suggests that dynamic stretching performed in slow and controlled movements in full joint ROM is more effective in increasing flexibility during warm-up (Fredrick and Szymanski, 2001; Hedrick, 2000; Mann and Jones, 1999). However, although data are consistent about the improvement of joint flexibility, literature is scarce on whether dynamic stretching can ameliorate explosive sports performance, such as sprints.

Additionally, although more dynamic-type exercises –such as calisthenics- are incorporated in warm-up sessions during soccer training, they are usually performed in a restricted ROM, and neither soccer players nor trainers seem to perceive the importance of proper integration. Since muscle length is completely depended on how the muscle is used during each movement (Van der Poel, 1998), it would be useful to delineate whether the performance of calisthenics is a key factor in improving joint flexibility and sprinting speed.

Thus, the main aim of this study was to examine the acute effects of static and dynamic stretching during warm-up, on the sprinting ability of amateur soccer players, in field conditions. The secondary aim was to determine the acute effect of stretching on joint flexibility during hip flexion, hip extension, hip abduction, knee flexion, and ankle dorsiflexion.

Methods

Participants

Eighteen amateur adult soccer players volunteered to participate in the study, initiated during the 10 days directly following the end of the competitive session. At this period, athletes participated in a total of 3 light-intensity soccer-training sessions. Participants agreed to restrain from all forms of strenuous physical activity during the study protocol. At the beginning of the study height and weight of participants was measured (Seca 789; Seca, Hamburg, Germany) and ROM was evaluated for both body sides. Mean age of the participants was 26.0±2.4 years old, height 175.3±2.8 cm, body mass 74.8±6.2 kg and average training age reached 15.3 years. All athletes were apparently healthy, in absent of any musculoskeletal or neurological disease. A sports medicine accredited doctor examined each participant thoroughly, before the initiation of the protocol. All athletes and their trainers were informed of the nature, aim and possible risks associated with the study, prior consenting to participate. The study was conducted in accordance to the rules and regulations of the research Ethics Committee of the University of Thessaly.

Procedures and stretching protocols

All participants performed 3 distinct flexibility protocols on non-consecutive sessions, each separated by at least 1 week from next, for every subject. The order the protocols performed by each athlete was random, so that the results would not be biased by the learning factor.

The first flexibility protocol comprised of the Control Treatment (1^{st} Protocol-Control). This included a) general soccer warm-up exercises for a total of 10 min, b) measurement of flexibility and sprinting speed c) static stretching exercises for a total of 5 min, and d) final measurement of flexibility and sprinting speed. Each stretching exercise lasted for 10 sec, and was repeated once more for each muscle group (2x10sec), with a 10 sec rest interval between sets, during which the muscle groups involved were in full static stretching. This position was a terminal one, defined as the point to which the subject felt the stretch, without experiencing any pain. For all stretching exercises the positions were assumed gently and slowly until the actual end-point of the range. The working muscle groups involved the hamstrings, quadriceps, adductors, hip flexors and soleus.

The second flexibility protocol was considered the first experimental treatment protocol (2^{nd} Protocol- 1^{st} Experimental Treatment). This included a) the same exercises of general soccer warm-up exercises for a total of 10 min, b) flexibility measurement and sprinting ability measured, c) calisthenics without a full ROM, for a total of 5 min, and d) final measurement of flexibility and sprinting ability. The calisthenics involved the whole body and in particular the lower extremities joints. Each exercise was performed in repetitions of 10 sec, starting at a small motion arc and increasing the arc in each repetition so that the last few were exaggerated (Sobel et al., 1995). The cycle was repeated once more for each muscle or muscle group (2x10 sec).

The third flexibility protocol consisted of the second experimental treatment protocol (3^{rd} Protocol- 2^{nd} Experimental Treatment), which was similar to the second, expect for the calisthenics (5 min) that were now performed in a full ROM. As in the second protocol, the working muscle groups involved the hamstrings, quadriceps, adductors, soleus and hip flexors.

The general soccer warm-up comprised of low-intensity aerobic exercises, including jogging towards multiple directions with or without a ball, as performed in the general warm-up sessions prior to each competition. The protocols were performed in the field by two experienced sports-scientists. Throughout the protocol, each scientist was assigned with the same responsibilities and performed the same measurements. Detailed instructions were provided to the participants prior to each protocol for completing and performing the exercises and the sprints. The same scientist recorded the results in a detailed database.

Flexibility measurement

Five ROMs of the lower extremities (hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion with the knee flexed) were measurement. All joints were measured with the use of a Myrin flexometer (Lic Rehab. 17183 Solna, Sweden) according to the Ekstrand et al. (1982) method. This flexometer is a modification of the Leighton flexometer and consists of a circular scale with a weighed pointer controlled by gravity attached to the centre. The variation coefficient for the method of goniometric measurements was high (1.9± 0.7%).

All measurements except for ankle dorsiflexion were performed on an adjustable bench on the right side. Only the right side was measured because the statistical analyses of the recruitment data failed to show significant differences between the right and left body sides of the participants ($p>0.05$). Each movement's initial and final positions were passively measured starting from a 0° point, as defined by the American Academy of Orthopaedic Surgeons (1965). Maximal flexibility was determined as the point where the joint attained end-range, which was defined as the point at which the examiner felt muscle restriction (Ferber et al., 2002). All pre-test and post-test measurements were taken at approximately the same time of day, while participants abstained from any training or other type of exercise during the 48h preceding the experiment. The reliability coefficient of each measurement was high: hip flexion $r=0.93$, hip extension $r=0.92$, hip abduction $r= 0.91$, knee flexion $r=0.93$ and dorsiflexion $r=0.90$.

Running velocity test

All subjects performed two separate maximum trials for each test of 20m straight sprints, with a rest interval of at least 2 minutes between each effort. The best performances in each test were used for the analyses. Measurements were performed with the use of New test Power timer 300 photocells (PC Upgrade Kit, FIN 90220 Oulu, Finland). Two photocells were set in a 20m distance, as suggested by the manufacturer. The first photocell was situated at the starting line (0 m) and the second at the 20m finishing line. Each soccer player initiated the sprint from a standing position distanced 40cm from the first photocell and gradually reached maximum speed until the final cone, which was situated 5m after the second photocell, in order to control for a possible speed reduction while reaching the 20m finishing line. Photocells were situated 80cm above ground, according to manufacturer guidelines.

Statistical Analyses

A mixed within- and between-subjects 3x2 ANOVA model with repeated measures over tests was applied for each dependent variable. The repeated factor was the test that had two levels (pre-post). The between-subjects' factor was the flexibility treatment protocol and had three levels (control and experimental treatment protocols). When significant values were found, Scheffé's post hoc analysis was applied to determine the significance of the relationship of the means. It addition, when significant interactions were noted, these were further broken down using analysis of simple main effects. Statistical significance was set at the 95% level ($p<0.05$).

Results

The analysis revealed a highly significant main effect for the test in hip joint flexion ($F_{1,51}$=38.04, p=000), hip joint extension ($F_{1,51}$=16.80, p=000), hip joint abduction ($F_{1,51}$=95.43, p=001), knee joint flexion ($F_{1,51}$=16.00, p=000), ankle joint dorsiflexion ($F_{1,51}$=105,80, p=000), and in the sprint ($F_{1,51}$= 28.45, p=001), indicating differences in the ROM and the sprint speed between the three protocols. The statistical analysis revealed a highly significant test for the flexibility treatment protocol interaction in hip joint flexion ($F_{2,51}$=30.26, p=000), hip joint extension ($F_{2,51}$=13.85, p=000), hip joint abduction ($F_{2,51}$=36.47, p=000), knee joint flexion ($F_{2,51}$=11.04, p=000), ankle joint dorsiflexion ($F_{2,51}$=20.68, p=000), as well as in the sprint speed ($F_{2,51}$=16.35, p=001), suggesting that the effect of flexibility depended on the examined protocol. To further break down this interaction, paired t-tests were separately performed for each flexibility protocol in order to examine possible differences in each joint ROM and sprint speed before and after the flexibility regimen. As stressed in Table 1, a significant increase was recorded in all joint ROMs ($p<0.001$), accompanied by a significant retardation in the sprint ($p<0.01$) (Figure1), immediately after the implementation of the control protocol, including static stretching exercises. After the experimental treatment protocol including calisthenics performed in a restricted ROM, a significant increase was demonstrated only in the ankle joint dorsiflexion ROM ($p<0.05$) (Table1), accompanied by a significantly faster sprint ($p<0.05$) (Figure1). The experimental treatment protocol including calisthenics in a full ROM yielded significant increases in all measured joint ROMs ($p<0.001$) (Table 1), as well as a significantly faster sprint ($p<0.01$) (Figure1).

Table 1. Five range of motion in 18 amateur soccer players before and immediately after the flexibility sessions. The values are expressed as mean ± SD

	1st Protocol (Degrees) Control Treatment			2nd Protocol (Degrees) 1st Experimental Treatment			3rd Protocol (Degrees) 2nd Experimental Treatment		
	Pre#	Post$	p	Before #	After$	p	Before	After	p
Hip flexion	68.6±7.9	74.8±7.4	p<0.001	68.3±7.3	69.1±7.1	NS	68.4±7.5	75.6±7.1	p<0.001
Hip extension	65.1±7.0	70.7±7.2	p<0.001	65.7±6.8	66.4±6.1	NS	65.2±7.3	72.3±7.5	p<0.001
Hip abduction	41.3±3.9	47.2±4.2	p<0.001	41.1±4.2	42.3±4.4	NS	41.1±4.0	48.8±4.2	p<0.001
Knee flexion	135.2±8.8	140.8±8.6	p<0.001	135.6±8.4	136.4±8.0	NS	135.4±8.4	142.4±8.6	p<0.001
Ankle dorsiflexion	27.2±3.0	31.7±2.8	p<0.001	27.4±2.8	30.6±2.6	p<0.05	27.6±2.8	32.7±3.0	p<0.001

Initial values, $ after flexibility sessions, NS: non significant

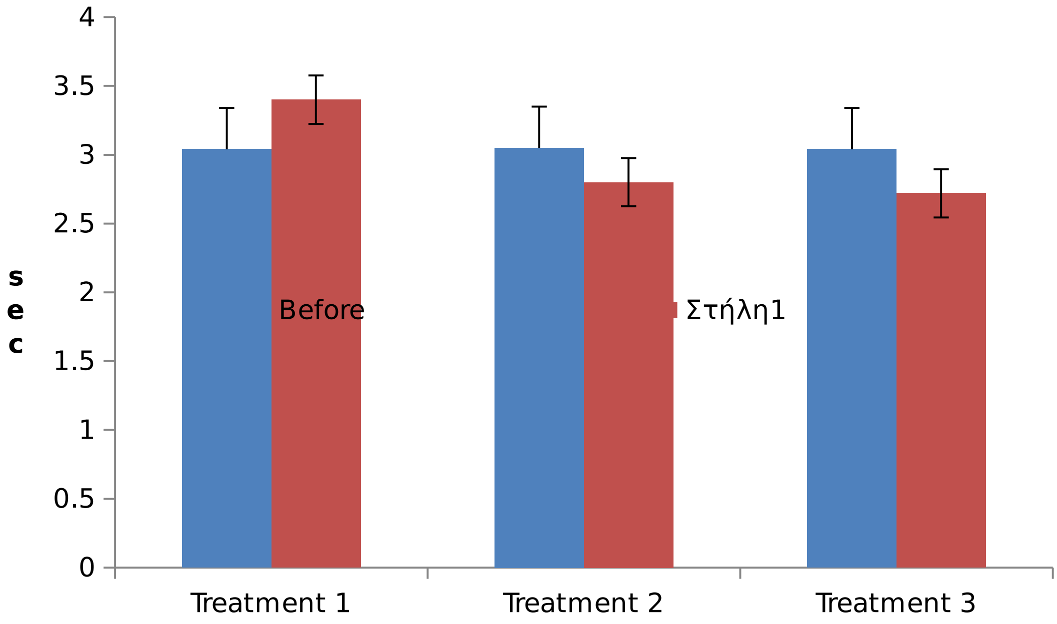

Figure1. Duration (sec) of 20 meter sprint performed by 18 amateur soccer players before and immediately after the implementation of different flexibility warm-up sessions. Values are means; Error Bars = SD; * $p<0.05$, ** $p<0.01$

Discussion

The present study was designed to assess the direct effects of static and dynamic low-extremities stretching performed immediately after low-intensity aerobic soccer warm-up exercise, on the sprinting speed and joint flexibility of amateur adult soccer players. The results revealed that 20 seconds of static stretching performed immediately after general soccer warming-up, significantly reduces post-warm-up 20m sprinting speed. This finding is in agreement to previous research, deeming static stretching as hampering for sprints (Gelen, 2010; Chaouachi et al., 2008; Winchester et al., 2008; Nelson et al., 2005; Fletcher and Jones, 2004).

Although the protocol herein was not designed to delineate the exact mechanism explaining this result, several scientists have tried to resolve the stretching-induced reduction in sprinting speed. Suggested possible mechanisms include neural inhibition (Behm et al., 2001; Fowles et al., 2000) and mechanical factors involving the viscoelastic properties of the muscles that may affect the muscle length-tension relationship (Nelson and Sidaway, 2002). Low muscle temperature and low blood circulation post-static stretching have also been postulated as sprint performance bottlenecks (Mohr et al., 2004; Poole et al., 1997). However, the precise mechanism propelling the static stretch-induced sprint impairment remains unclear (Behm et al., 2001).

Although results indicate that a 20sec static stretching hampers 20m sprinting ability in amateur soccer players, the dynamic stretching of the lower extremities muscles, performed at the same duration and under the same conditions, appears to improve sprinting ability irrespectively of the ROM attained during the performed exercises. Although this finding appears consistent in literature, it cannot be directly compared to those of similar studies, mainly due to methodological differences (Gelen, 2010; Fletcher and Monte-Colombo, 2010; Fletcher and Jones, 2004). As static stretching was considered obsolete for athletic performance, alternative exercises were integrated in the warm-up sessions in order to increase sprinting speed. Thus, sport scientists, coaches and athletes started using dynamic exercises emulating the movements performed during the actual training or competition (Faigenbaum et al., 2006). These types of dynamic exercises include load resistance exercises and plyometric movements, usually in the form of high-knee pulls, skipping, carioca, various jumping exercises and gradually increasing acceleration movements (Thompsen et al., 2007). In both experimental protocols herein, static stretching was substituted by gymnastics exercises performed in a rhythmical dynamic pace, with the muscle groups implementing concentric and eccentric contractions akin to the contractions taking place during a sprint. According to Fletcher and Jones (2004), stretching exercises of dynamic nature are more specific to the movements made during the sprint, in contrast to exercises of static stretching nature.

Several factors have been proposed in literature as potential explanations of the improved sprinting speed and/or dynamic-type muscle elongation conferred by dynamic stretching. According to Little and Williams (2006), the improved sprinting ability might be the epiphenomenon of increased muscle and body temperature. Prolonged duration of warm-up elevates muscle temperature and speeds up neural transmission (Bishop, 2003), whereas static stretching tends to reduce cardiac output and subsequently muscle and body temperature (Fletcher and Monte-Colombo, 2010). The rise in muscle temperature reduces muscle resistance and joint tightness (Fletcher and Monte-Colombo, 2010) while increasing the neural receptor sensitivity and concurrently facilitating contraction, making it faster and stronger (Shellock and Prentice, 1985). As Hedrick (2000) suggests, increased muscle temperature contributes to a more dynamic muscle contraction and a faster relaxation. Although muscle temperature was not measured in the present study, sweating -a direct result of increased muscle temperature- was observed in all participants and could partly explain the recorded improvement in sprint speed.

Additionally, the improved sprinting ability could stem from neurological factors. According to Gollhofer and Rapp (1993), the myotatic reflex could be related to the speed of the performed stretching exercise and this in turn might have a hardening effect on musculotendinous (Houk and Rymer, 1981). This is why, in order to improve athletic performance, dynamic exercises must be performed in a repetitive dynamic manner (Hedrick, 2000). In the present study calisthenics were performed in a repetitive dynamic rigorous pace for a total duration of 20sec.

The results indicate that the 20sec static stretching and the calisthenics performed in full joint ROM, performed directly after the general soccer training exercises, can both induce improvements in the lower extremities joints ROM. In contrast, calisthenics performed in a restricted ROM, for the same duration and under the same conditions, only confer improvement in the dorsiflexion ROM and not in the rest of the lower extremities joints. Wiktorsson-Moller and his colleagues (1983) also reported a similar finding, after a 15min warming-up session on the cycle-ergometer. This improvement in the dorsiflexion flexibility further corroborates previous research using acute stretching conditions (Zakas et al., 2006) or involving a long-term stretching protocol (Knight et al., 2001) and has been attributed to the contraction/relaxation cycle of the triceps surae, as a result of the dynamic elongation conferred during cycling.

In the present study, the improvement in dorsiflexion ROM might be the epiphenomenon of the dynamic elongation of the muscles during the general warm-up session, which included low-intensity jogging with and without a ball. Although it is generally accepted that increased muscle temperature improves joint flexibility (Sapega et al., 1981), this effect cannot be produced without passive or dynamic muscle stretching (Zakas et al., 2006; Zakas et al., 2003; Shrier and Gossal, 2000). According to Van der Poel (1998) muscle length is completely depended on how the muscle is used during each movement.

Until fairly recently, the effect of increased muscle temperature on the improvement of flexibility was attributed to the connective tissue's extensibility alterations, as it was believed that flexibility was dependent on the length of the connective tissue (Sapega et al., 1981; Warren et al., 1976). However, the role of the connective tissue in flexibility appears to have been overestimated, whereas the myogenic constraints in determining ROM appear to have been underestimated (Hutton, 1992). Previous findings further consolidated this theory (Hill, 1968; Magid and Law, 1985), suggesting that the elongation induced after active or passive stretching is actually the result of disconnected myosin-actin cross-bridges. However, further research is needed in order to delineate the mechanisms involved in the joint flexibility conundrum.

Conclusion

In a nutshell, the results herein indicate that 20m-sprint speeds improved when dynamic stretching in the form of calisthenics performed in either full or restricted ROM, is incorporated in soccer warm-up sessions. Additionally, it is evident that static stretching or dynamic stretching such as calisthenics in a full ROM for duration of 20sec can equally improve joint flexibility. Thus, coaches and soccer players wishing to improve both sprint speed and joint flexibility should be proactive and incorporate dynamic type stretching exercises performed in full ROM, in the warm-up session.

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