Acute Effects of Ballistic vs. Passive Static Stretching Involved in a Prematch Warm-up on Vertical Jump and Linear Sprint Performance in Soccer Players

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Abstract

López Mariscal, S, Sánchez Garcia, V, Fernández-García, JC, and Sáez de Villarreal, E. Acute effects of ballistic vs. passive static stretching involved in a prematch warm-up on vertical jump and linear sprint performance in soccer players. *J Strength Cond Res* 35(1): 147–153, 2021—The purpose of this study was to compare the effects of introducing passive static and ballistic stretching in a standard soccer match warm-up. The variables addressed were the counter movement jump (CMJ), Abalakov jump, and the 40-m linear sprint. The sample was composed of 33 male subjects, divided into 2 age groups. U16 and adult players formed the groups, to cross check whether there were differences between them. Each group was further subdivided into 2 groups regarding the type of stretching carried out during the stretching phase. Before the warm-up, the tests previously described were assessed. In the experimental phase, standard stretching was carried out, consisting of an initial phase in which players had to execute continuous running; a general phase in which players had to make articulate moves; a technical phase in which players had to execute exercises with the ball; a 5 vs. 5 small-sided game was carried out during the tactical phase; and in the final phase, activation exercises and sprints were carried out by the players. Eventually, the same variables were assessed again once the warm-up was finished. There were no statistically significant differences between the 2 types of stretching included in the prematch warm-up. It can be concluded that ballistic and passive static stretching (<10 seconds) did not cause, under these circumstances, any effect in the assessed variables related to soccer performance (linear sprint, CMJ, and Abalakov). This has to be considered by coaches when devising soccer-related warm-ups.

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Introduction

Soccer is one of the most played sports in the world, and according to the Fédération Internationale de Football Association activity report in 2016 (16), more than 60% of the global population is involved as a player, a coach, a referee, or has general experience in soccer.

In sports, and especially in soccer, it has been proven that one of the most important factors to get the best performance in athletes is to have a good physical condition. Apart from the technical improvement, medical support, nutrition, new equipment, etc., physical conditioning has experienced a great evolution in the last few years, both in quantity and quality. In the last decades, sports science has evolved a lot and, as a result, there has been a huge progress in soccer physical conditioning at all levels (5).

A great amount of studies related to stretching and the acute effect that they cause to the performance of different athletic groups have been recently published, trying to find out which kind of stretching is the most suitable for each sport (1–4,7,8,11,12,19–21,23–27,28,29–31).

Within the existing literature, it is possible to find that the most frequent types of stretching are static stretching (SS), proprioceptive neuromuscular facilitation, ballistic stretching (BS), and dynamic stretching (DS); although the difference between BS and DS is not clear, they will be treated as equal (21).

So far, SS has been carried out in a warm-up before the competition because it was believed that they reduced injury risks. There are studies that show how the rate of muscle, ligament, and tendon injuries are reduced in trained subjects; however, the muscular pain feeling persists (10,12,18,26). Moreover, the SS can cause an enhancement of the range of motion (ROM) and variable tied to injury risk (32).

Nevertheless, there are studies, where SS and DS are included, that suggest that the DS(s) causes a greater impact on the ROM (3). Currently, it has been proven in many studies that the SS(s) has a negative effect on linear sprint (7,12,23,27), vertical jump (12,27), balance (8), and agility (8,24) performance because of a reduction on the peak torque (31), contraction velocity (31), power peak (27) reduction in sensitivity of the muscle spindles (6,7), causing a decrease in the muscle activation, and nerve impulses (7,24).

The SS causes a lower performance because of decreased muscle activation and less musculotendinous stiffness, although it is also likely that these negative effects are due to the long-lasting SS, meaning an increase of muscular pain and muscle damage indicated by a high level of creatine kinase in the blood (7,24,27). However, there are some articles in the literature that show how the SS do not produce the decreased performance (11,19,26,29), whereas other studies conclude that the DS is more beneficial than the SS (1–4,7,8,11,12,19,23–26), there are improvements on sprint (7,12,19,23), agility (2,8,19,24,26), vertical jump (12,25), and balance (8) because of improved post-activation potentiation (1,11,19,24), stimulation of the nervous system (8,19), increasing the sensitivity of nerve receptors and increasing the speed of nerve impulses (19).

In some articles, interventions were carried out to cross check the acute effect of stretching. Among those, we would like to highlight a study comprising 12 sessions of stretching intervention. It was proved that after the DS, the initial values were preserved in the agility test, whereas the SS intervention worsened the agility test performance regarding the initial values (24). Carrying out the DS in warm-up for 8 weeks improved the vertical jump in power, force, and height (squat jump and counter movement jump [CMJ]) variables. Flexibility also improved, but neither the repeat sprint ability (RSA) nor the linear sprint acceleration improved. From 3 to 8 weeks, the DS can lead to adaptations in skeletal muscle elastic properties (25).

Moreover, there are some studies where the RSA has been measured. A study in which static and DS were carried out, and their impact was measured after 24 hours, which did not show a significant difference on RSA (12); however, in a different study, it is shown that after a 2-week DS protocol, RSA performance improved (29).

Therefore, all the revised articles so far establish a quite long stretching protocol, which, in our opinion, does not fit soccer precompetitive reality. That is the reason why we wanted to propose a more realistic protocol in relation to what really happens before a match, and for that purpose, on the basis of the hypothesis that stretching included in soccer warm-up can influence the jump and sprint performance, 2 main objectives are established: (a) comparing the impact that could be caused by introducing passive static and BS in a soccer match standard warm-up, regarding jump (CMJ and Abalakov) and linear sprint in 40-m variables and (b) comparing the possible impact of the previous protocols in different age groups.

Methods

Experimental Approach to the Problem

This study was designed to determine the impact of 2 types of stretching on sprint and vertical jump performance in soccer players from 2 different age groups. Thirty-three subjects used to soccer training were involved. They executed a pretest to measure linear sprint in 10, 20, and 40 m, CMJ height and Abalakov jump height. Thereafter, the subjects executed a standard soccer warm-up differentiated only by the types of stretching carried out. Two groups executed SS, whereas they other 2 executed a BS. Once the intervention was finished, the players executed a posttest to monitor the impact that had been caused in the assessed variables. During each protocol, the subjects were instructed in the proper execution of all the exercises and warm-up while being supervised by the coaches.

Subjects

All the subjects were volunteers, and the guidelines set by the Declaration of Helsinki (2013) and the Sport and Exercise Science Research ethical considerations (14) were followed. Written informed consent was received from adults and from under 18 players' parents or legal guardians. Both clubs' board of directors and coaches in charge were fully informed. The study was approved by the University of Pablo de Olavide.

The subjects were divided into 2 different age groups. A total of 33 male subjects participated in the study, and they were divided into a Junior Group comprising those with ages between 14 and 15 years (G1 and G2 = n13) and a Senior Group comprising those who are aged 19 years and older (G3 and G4 = n20). Each of the groups were informed about the objective and the evaluation methods, that is why they had a session to familiarize them with technical gesture and to have a previous contact before doing the study.

Each group of amateur and U-16 players has been used and assigned in each group homogeneously and randomly in 2 subgroups for each category involved.

Procedures

The study was carried out in the first half of the season, after the preseason, with a pre-test and a post-test the same day. The interval between tests was 20 minutes long, and during that time, the players executed the warm-up that included the stretching protocol designed for each group. It was a 2-day long intervention. In the first day, a familiarization session was carried out, whereas in the second one, data collection for the study was conducted. In the first day, an orientation session was carried out, introducing the types of jump that the subjects were about to perform such as Abalakov and CMJ along with linear sprint. For that purpose, the same session without a ball, which included movement exercises in 5–10 m with combinations of jump and sprint, was organized for each group.

Table 1. Stretching program.

	Static	Ballistic
Hamstring	A hip flexion with knee extension on the stretched leg, resting the heel followed by an ankle dorsal flexion.	We start from a standing position, and we swing the stretched leg extended ahead, carrying out a hip flexion.
Quadriceps	The players' position starts from standing, followed by a knee flexion bringing the heel closer to the gluteus.	From standing position we swing the stretched leg making a hip extension and knee flexion simultaneously.
Psoas iliac	Hip extension with the leg stretch and a knee flexion on the other leg.	From a standing position, we unbalance the body ahead, and we swing the stretched leg back, making a hip extension.
Abductors	Knee flexion in the frontal plane on the supporting leg carrying out a hip extension and abduction on the stretched leg.	We start again from the standing position; we are going to swing the leg laterally this time causing a hip abduction.

A progression before making the specific gesture was carried out for each jump and series of 40 m with the purpose of adapting players to this distance, avoiding deceleration before reaching the goal in linear sprint. For this protocol, subjects were informed that they were not allowed to do physical activity during the 48 hours before the intervention.

The evaluation was made a week after carrying out the familiarization session and once the intervention that was going to be performed was explained. First, the players executed the pretest and 3 measurements of each performance variable assessed were carried out. Second, the players executed a standard warm-up, that is to say, a usual type of warm-up before the competition, where a stretching protocol was included for each group. Last, after the intervention, performance variables were measured again during the posttest, as they were measured before this intervention.

Tests were arranged in the following way: CMJ, Abalakov, and linear sprint in 10, 20, and 40 m.

Procedural Measures. All the measures were taken in synthetic grass surface wearing the usual footwear for this sport. Great care was taken in the recovery between all the events to limit the fatigue that they caused.

Vertical jump in soccer is intended to reach the maximum height of the center of gravity through flexion-extension of the lower body, by moving the arms to reach a greater height. A concentric muscle activation is produced, preceded by a short eccentric contraction phase during the counter movement, where elastic energy is accumulated.

Counter Movement Jump. The subject's initial position was in a standing position, erected body, and with their legs open at shoulder level, placing the arms akimbo holding the waist, so, in that way, all the strength that performs during flight time is muscular strength from the lower body, as it is reflected in scientific literature previous to this study (9).

Abalakov. The subject's initial position was in a standing position, erected body, legs open at shoulder level, and arms straight up to profit arm movement and recreate in that way the specific jumping movement in soccer and to profit kinetic energy from arm swinging. During flight time, legs are totally extended (13,15).

The assessment was made through Optojump system (Microgate, Bolzano, Italy). Three jumps were carried out with 1 minute of rest.

Linear Sprint assessment (20, 30, and 40 m). The accelerating competence and the maximum speed in 40 m was assessed by sprinting along 40 m, recording the time at 20 and 30 m, for this purpose, photocells were used (Microgate).

Photocells were placed at the start, 20 m from the start, 30 m far from the start, and, the last one, 40 m far from the start, telling the players that they had to run at maximum speed from the start to the last photocell.

The start was signaled with 1 foot forward on the mark, 0.5 m from the first photocell, with the trunk slightly bent forward. The first photocell was placed at a smaller height than the rest to avoid a variation in the results because of upper limbs. The rest of the photocells reached the players' waist level. Each player had 2 attempts, another one if necessary.

Warm-up Procedures. The warm-up carried out was the same one for all the groups, a prematch standard warm-up, which consisted of the following phases: initial phase, general phase, technical phase, tactical phase, and final phase (Table 1). Both warm-up and tests were carried out in a synthetic grass soccer field. The warm-up was carried out for 18 minutes; however, if the stretching time between phases was considered, the total duration would be 21 minutes.

The warm-up consisted of an initial phase (3′) during which players had to run gently and to carry out free movements. During the general phase (4′), players carried out general movements led by the coach, after a progression in intensity. In the technical phase (4′), players had to arrange themselves into groups of 2, and they also had to carry out free passing drills. Then, in the technical phase (5′), a ball possession task was established for each subgroup, and lastly, a final phase (2′) was conducted with some activation exercises, executing accelerations and sprints.

Between the phases, stretching exercises were carried out in 1 minute and 30 seconds, working with muscles in the front and back part of the thighs (quadriceps and hamstring, respectively), iliopsoas, and abductors. In passive stretching, a 10-second stretching exercise was carried out for each leg and muscle group, whereas for BS, 8 repetitions for each leg and muscle group were carried out.

The stretching exercises were used twice. Both had a duration of 1 minute 30 seconds, executing the first protocol between the general phase and the technical phase and the second one between the tactical phase and the activation phase. The muscle groups involved were hamstring, quadriceps, iliopsoas, and abductor muscles.

Each muscle group from each leg was involved in a 10-second SS, whereas for the BS, 8 repetitions for each leg and muscle group were carried out.

The same coach conducted the warm-up, so the whole group carried out the same warm-up in order not to vary the sample. In that way, we would avoid doing the exercises with different intensity or duration. The group was divided into 2 groups with bibs of different colors, so that at the end of the general and tactical phase, a group would carry out SS with a coach and the other group would carry out BS with a different coach. Furthermore, the nutritional status and the hydration were monitored during the data collection process. Eating was not allowed during the 4 previous hours and drinking was not allowed the last hour before the data collection.

Statistical Analyses

Descriptive statistics (mean ± *SD*) for the different variables were calculated; the intraclass correlation coefficient was used to determine the reliability of the measurements. The training-related impact and the differences between groups were assessed using a mixed design factor analysis of variance using the Snedecor F-Test. One-way analysis of variance procedure and Bonferroni post hoc test were carried out to identify the differences between groups and intragroups. Effect sizes (ESs) were also calculated using Cohen's *d*. Furthermore, the percentage change was calculated to monitor the differences between the pretest and the posttest. Statistical significance was accepted at an alpha level of

Table 2. Sprint 20 m (seconds), Sprint 30 m (seconds), Sprint 40 m (seconds), CMJ (cm), and Abalakov (cm) performance of the different groups.*†

	Static passive stretching							
	Young players				Adult players			
Variables	Pre	Post	%	ES	Pre	Post	%	ES
Sprint 20 m	3.20 ± 0.04	3.22 ± 0.05	0.62	0.50	3.01 ± 0.04	2.99 ± 0.03	−0.66	−0.50
Sprint 30 m	4.40 ± 0.07	4.49 ± 0.07	2.04	1.28	4.18 ± 0.05	4.17 ± 0.04	−0.23	−0.20
Sprint 40 m	5.69 ± 0.07	5.75 ± 0.10	1.05	0.85	5.33 ± 0.07	5.33 ± 0.06	0.00	0.00
CMJ	33.07 ± 1.93	33.90 ± 2.19	2.50	0.43	36.75 ± 1.42	37.64 ± 1.44	2.42	0.62
Abalakov	37.55 ± 2.03	38.05 ± 2.63	1.34	0.24	40.14 ± 1.51	39.62 ± 1.52	−1.29	−0.34
	BS							
	Young players				Adult players			
Variables	Pre	Post	%	ES	Pre	Post	%	ES
Sprint 20 m	3.19 ± 0.05	3.18 ± 0.05	−0.31	−0.20	3.06 ± 0.02	3.05 ± 0.03	−0.32	−0.01
Sprint 30 m	4.45 ± 0.07	4.42 ± 0.06	−0.67	−0.42	4.25 ± 0.03	4.25 ± 0.03	0.00	0.00
Sprint 40 m	5.70 ± 0.09	5.69 ± 0.08	−0.17	−0.11	5.42 ± 0.04	5.43 ± 0.04	0.18	0.01
CMJ	33.47 ± 2.72	32.61 ± 2.47	−0.86	−0.31	34.60 ± 0.66	35.48 ± 1.02	2.54	0.88
Abalakov	37.23 ± 2.55	39.05 ± 2.26	4.88	0.71	37.86 ± 0.89	38.48 ± 0.96	1.63	0.62

*CMJ = counter movement jump; BS = ballistic stretching; ES = effect size.
†Values are as reported as mean ± *SD*.

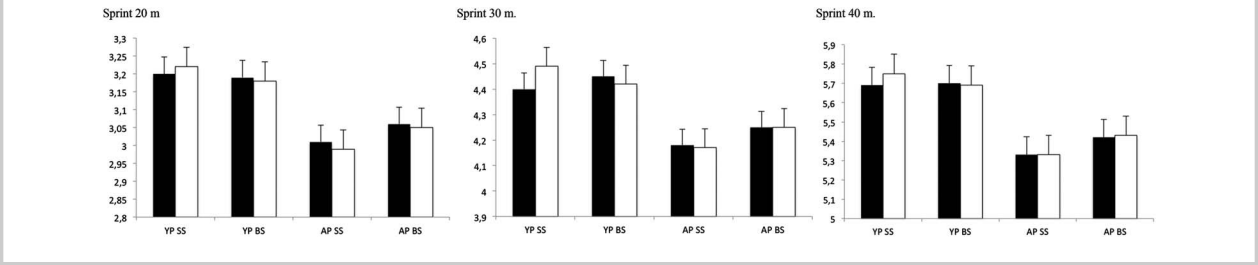

Figure 1. Sprint 20, 30, and 40 m (seconds) before and after intervention. Young players static stretching (YP SS), Young players ballistic stretching (YP BS), Adult players static stretching (AP SS), Adult players ballistic stretching (AP BS).

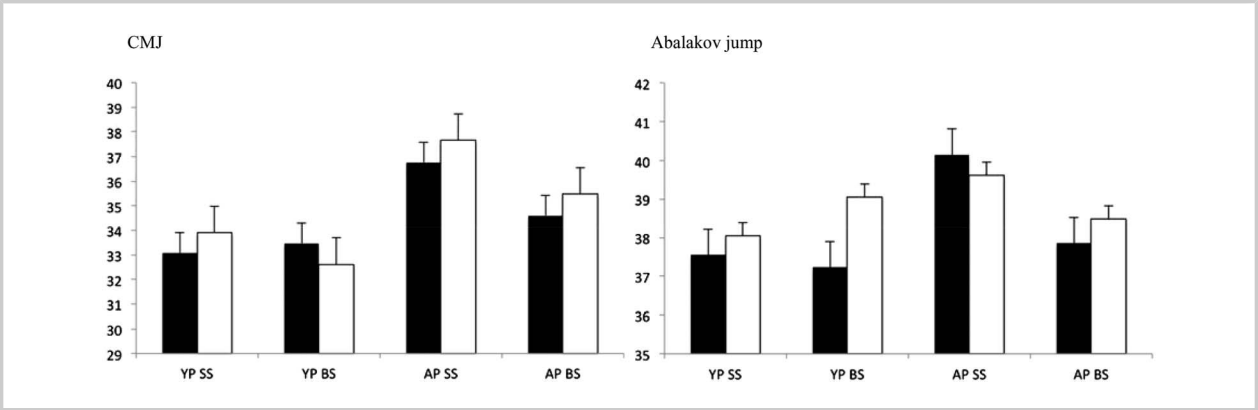

Figure 2. Counter movement jump and Abalakov jump (cm) before and after intervention. Young players static stretching (YP SS), young players ballistic stretching (YP BS), adult players static stretching (AP SS), adult players ballistic stretching (AP BS). CMJ = counter movement jump.

$p \leq 0.05$. SPSS Statistics 20.0 Windows software package was used to carry out all the analysis.

Results

There were no significant differences between the sprint and the vertical jump variables. In all the cases ($p \leq 0.05$; Table 2).

The pretest and the posttest did not show significant differences in any of the distances that were assessed for the sprint times (20, 30, and 40 m) for each of the same age groups of that carried out different types of stretching.

With respect of the jump height in CMJ (ES = 0.43; 0.62; −0.31; 0.88), no significant differences were found in any of the groups or based on the type of stretching included in the warm-up.

The Abalakov jump (ES = 0.24; −0.34; 0.71; 0.62) did not show any significant difference in tests taken by the groups that carried out SS and BS in the warm-up, the highest % change was performed by young players in BS (% = 4.88) (Figures 1 and 2).

Discussion

The analyzed results show that DS did not produce more benefits neither in linear sprint nor in vertical jump (CMJ and Abalakov) variables in young or adult players; these results contradict the revised literature (1–4,7,8,11,12,19,21,23–26). In the young players group, it can be noticed that the BS in warm-up has positive percentage of change, but it does not go beyond 5%. All the previous studies used standardized protocols, but they were not very realistic, and they differed from the real needs that are required in soccer. It is hard to think that a lengthy stretching protocol can be carried out before the competition. That is why it was necessary to design and present a protocol with scientific validity that could be recreated in any situation before the soccer match. The SS did not cause a different effect either in the measured variables or the analyzed age groups. Previous studies showed that the SS techniques (passive and active) can lead up to a reduction in sensitivity of nerve paths, reducing the muscle spindles activation of the stretched musculature, causing a decline in excitatory impulses (7). From a neurological standpoint, this type of stretching favors a decrease in neural impulses from the central nervous system (CNS) to the muscle that works during sprinting (23). In our view, it is not coherent to keep the muscle stretched statically for long in a warm-up because the objective of the warm-up is to adapt the system to the

requirements that it is going to face during the competition and, in most of the soccer movements, the stretching-shortening cycle is going to be involved. Ayala-Rodríguez F and Sainz-de-Baranda-Andújar P (7) make reference to the fact that an acute load of muscular stretching could threaten the stretching-shortening cycle efficiency because of a decline in the active stiffness of the muscle-tendon unit, reducing in that way the amount of elastic energy that can be stored and reused.

However, the results obtained do not back these theories; this can be due to the fact that the time we spent on the SS was not enough to inhibit the myotatic reflex, and the impact of the warm-up counteracted the SS acute effect, and these results differ from the literature that was reviewed (7,22,24,27). As it was mentioned before, the stretching protocols used in other studies last longer and they are not involved in warm-up; it seems that stretching for less than 30 seconds does not affect 10–20-m linear sprint in soccer players (29).

However, the warm-up that included a BS protocol did not show any enhancement in the players' performance. The anaerobic capacity enhancement is caused by an increasing muscle temperature, stimulation of nerves system, and some level of post-activation potentiation (8,24).

Unlike the SS, where mechanical factors involving the viscoelastic properties of the muscle that must affect the muscle's stretching tension and neural factors, reducing muscle activation or altering reflex sensitivity (24), the BS stimulates the muscle activation, increasing muscular stiffness to enhance the production of peak/maximum force. It seems logical that this type of stretching, in which the stretching-shortening cycle has a significant presence, cause an enhancement in the performance regarding the sprint variable because the muscle is in an optimum temperature to carry out the effort required, but the results we have obtained do not show an enhancement in the posttest after carrying out this type of stretching.

The sprint is a movement that implies the stretch-shortening cycle, as well as BS, so the musculature must be ready for the demands of the movements, due to the muscle activation that causes this type of stretching and the CNS stimulation (1,17,19). The BS can be considered as a means of prevention because it is similar to movements carried out during sport.

The protocol designed in this research did not cause benefits in sprint and vertical jump variables performance. This is important because it determines that introducing an SS protocol that lasts less than 10 seconds or SB in warm-up makes no difference.

So far, some studies concluded that stretching in a static way before the competition caused a decrease in peak power (27,30,31), but in our study, we prove that this is not entirely true. Thanks to the results that we have obtained, it can be asserted that a SS protocol that lasts less than 10 seconds in a standard soccer warm-up does not reduce the CMJ performance.

Nevertheless, it can be thought that it is advisable to carry out BS in the CMJ when the stiffness recruitment is greater and the stretch-shortening cycle is activated, so it is advisable as a preventive means.

The Abalakov jump is also analyzed in the jump variable, unlike the revised papers, as we thought it is very important because it is more similar to the jump that is carried out in a soccer match.

Moreover, it seems obvious that the use of BS leads to a better optimization of the intermuscular and neuromuscular coordination because the Abalakov is a coordinated jump, the use of the BS should improve the performance; however, this enhancement did not take place after the intervention. The BS results in an active contractile process, and the performance benefits obtained, favor motor control, increase muscle blood flow, which increase the sensitivity of nerve receptors, and increase the speed of nerve impulses, potentially encouraging muscle contractions to be more rapid and forceful (19).

So far, all the articles show standardized protocols that are not realistic regarding the precompetitive soccer situation and that used too long durations that are not common in precompetition warm-ups (19).

It was necessary to carry out a study that provided a practical application related to the amount of information that has been obtained over the last years, that is why our investigation was aimed at theoretical effects in a practical frame.

Practical Applications

This study suggests that the static and/or BS protocol can be carried out before a soccer match; therefore, if we introduce SS in warm-up there is not a decrease in the jump or sprint performance, provided that the stretching will not last more than 10 seconds.

After the warm-up, there was no performance improvement by using any of the protocols. Moreover, any negative effect was found in players' performance when analyzing the results.

Concerning the sensitivity to the protocol, the response to the intervention was the same in both age groups, meaning that we can apply it to young and adult players.

This study proves that warm-up has no impact in the performance variables analyzed, regardless the type of stretching protocol carried out.

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