Original Research

Acute Effects of Static and Proprioceptive Neuromuscular Facilitation Stretching on Agility Performance in Elite Youth Soccer Players

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ABSTRACT

Int J Exerc Sci 5(2) : 97-105, 2012. A warm-up is an important part of preparation for a soccer match. Stretching is typically part of the warm-up however, debate exists as to the most appropriate type of stretching to perform. The purpose of this study was to examine the effects of static and proprioceptive neuromuscular facilitation (PNF) stretching on soccer-specific agility performance in 14 male elite, premier league youth soccer players. Participants completed 4 trials of the Balsom agility test while dribbling a soccer ball. Height, age, and body mass were collected in trial 1 and participants were accommodated to the agility test during trials 1 and 2. Trials 3 and 4 were the static and PNF treatment trials that were administered after a standardized warm-up (control) in a randomized and counterbalanced manner. There were no significant differences between the difference scores of the static and PNF stretching conditions, $P = .66$. Furthermore, no significant differences were found between the control and stretching trials for static stretching, $P = .15$ or between the control and stretching trials for PNF stretching, $P = .58$. Neither mode of stretching significantly affected agility performance. More research is needed to determine the chronic effects of PNF stretching on agility performance.

KEY WORDS: Warm up, PNF, game preparation

INTRODUCTION

Soccer is a sport characterized by high-intensity, intermittent, exercise including sprints of varying duration, rapid acceleration, jumping, and agility (21). While high-intensity actions contribute only 11% of the total distance covered during a match, they represent the more crucial moments contributing to the scoring or conceding of goals (22). As such, a players' performance on tests to measure rapid acceleration and change of direction will help to determine performance outcomes in a game.

Traditionally, agility tests have been performed to test rapid acceleration and change of direction. While several agility tests exist, such as the Illinois and the 505 agility tests, the Balsom agility test is a more soccer specific agility test because the movement patterns are similar to those used in soccer (39). Also, these agility tests are primarily performed without a ball, which is non-representative of a game situation because maintaining control of the ball is an important aspect to the game. Therefore, some modification is needed to test soccer-specific agility.

A sport-specific warm-up is an important part of preparation for a soccer match as strains to muscles and tendons have been shown to be associated with inadequate warm-up exercises (10, 19, 36). Both the American College of Sports Medicine (ACSM) and National Strength and Conditioning Association (NSCA) recommend a general warm-up consisting of aerobic exercises, followed by more sports-specific movements and light stretching before any physical activity or athletic competition (1, 3).

However, debate exists as to the type of stretching that should be included. Traditionally, static stretching has been performed prior to competition; however, there is evidence in the literature that static stretching may have a detrimental effect on sports performance (13, 17, 29, 33). Static stretching is a type of stretch that involves holding a stretch at the end position for 30 seconds and includes both relaxation and concurrent elongation of the stretched muscle (3). More recently, dynamic stretching has been proposed to be a better method of stretching prior to competition and has been shown to have a positive or neutral impact on performance (2, 5, 6, 13, 14, 17, 20, 21, 26, 27, 29). Dynamic stretching is a type of stretching that involves sport-specific movements to prepare the athlete for activity (3). Both dynamic and static stretching have the advantage of being performed individually, however they may not elicit the greater gains in range of motion (ROM).

PNF stretching is also a common mode of stretching. PNF stretching techniques are commonly used in both athletic and clinical settings to enhance both active and passive ROM to optimize motor performance and rehabilitation (34). While static, ballistic, dynamic, and PNF stretching are all effective at enhancing joint ROM (23, 24, 40), PNF stretching produces a greater enhancement (11, 12, 16, 25). PNF stretching is thought to be superior to other stretching methods because it facilitates muscular inhibition (3). PNF stretching involves three specific muscle actions to facilitate the passive stretch (3). To achieve autogenic inhibition, both isometric and concentric muscle actions of the antagonist are used before a passive stretch of the antagonist (3). To achieve reciprocal inhibition, a concentric muscle action of the agonist is used during a passive stretch of the antagonist (3). The main goal of any PNF stretching technique is to activate the Golgi tendon organs (GTO), a mechanoreceptor which is sensitive to increases in muscle tension and, when stimulated, causes a muscle to reflexively relax thus increasing ROM.

While studies have been conducted to assess the effect of PNF stretching on increased ROM (8, 35, 42) and vertical jump performance (4, 6, 7), the authors are unaware of any published studies that have examined the effect of PNF stretching on agility performance. This lack of studies on agility performance is surprising given the fact that PNF is commonly used by trainers on the sidelines of many sporting events such as soccer that heavily involve an agility aspect to the game. Information regarding PNF's effect on performance is needed to determine if PNF is beneficial or detrimental to performance in sports requiring high levels of agility. Therefore, the purpose of this study was to investigate the effects of static and PNF stretching modalities on a soccer specific agility test in elite male youth soccer players. It was hypothesized that PNF would produce a greater decrease (improvement) in the time to complete the agility course than static stretching.

METHODS

Table 1. Demographic Characteristics of the Youth Male Soccer Players (*N* = 14).

Variable	*M*	*SD*
Age (yr)	13.6	.6
Height (cm)	162.8	9.2
Body Mass (kg)	53.1	11.6

Note. M = Mean, *SD* = Standard Deviation.

Participants

The participants in this study included 14 male elite, Division I (premier league) U14 youth soccer players from a team in the southeastern United States. This team was chosen as a convenience sample of elite youth players. The age range of the participants was 12 years-14 years with the majority being 14 years of age (*n* = 10). Other demographic characteristics are presented in Table 1. To assure there were no physical injuries at the time of data collection, players and coaches were interviewed. Prior to participant recruitment, approval was sought and granted by the university institutional review board. All participants and their parents/guardians received written and verbal instructions regarding the nature of the investigation and gave their verbal and written informed consent to participate in this study. Participants were also informed of their right to withdraw from the study at any time without penalty.

Procedures

During trial 1, the participants' height and body mass were recorded. Body mass was recorded in kilograms to the nearest 0.1 kg via a scale (SECA, Hanover, MD) with participants dressed in shorts and a shirt. Height was measured with a stadiometer (SECA, Hanover, MD) to the nearest 0.1 cm. Participants were asked to remove their soccer cleats for both measurements.

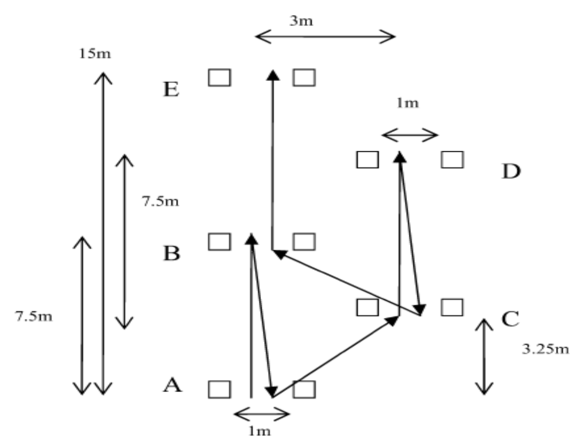

Figure 1. Balsom Agility Course (13).

All participants in this study completed 4 trials of the Balsom agility test; each trial was separated by at least a 48-hour period of recovery. The protocol for this test has been previously published (13). Briefly, the participant began the test at point A and ran to point B, then turned and ran back to point A before running through point C to point D, then turned and ran back through point C before running through point B to the finish at point E (see figure 1). Timing gates (Brower Timing System; Draper, UT) were placed at point A and point E with participants standing 0.5 m behind the starting gate at point A. Trials 1 and 2 were familiarization trials to allow participants to become accustomed to the testing protocol with no stretching treatment performed on the participants during these trials. None of the participants had previous experience with the Balsom agility test; therefore each participant was permitted to run the course as many times as he wanted during trials 1 and 2. It was the hope of the researchers that this would attenuate the learning curve for the testing protocol to provide a more accurate evaluation of the effect of the treatment.

Using a repeated measures experimental design, the order the participants completed the stretching conditions (trials 3 and 4) was randomly assigned. During trials 3 and 4, participants remained blinded to the purpose of the testing with no feedback on their performance being provided until all participants completed trials 4. Prior to trials 3 and 4, participants completed a standard warm-up. This consisted of 3 minutes of light jogging (self-selected pace) followed by 2 minutes of passing/running with a soccer ball. Immediately, after completion of this warm-up, participants completed the Balsom agility test with the soccer ball and this served as the control trial. Timing of the agility test was recorded electronically using a twin-beam photocell timing gate system (Brower Timing System; Draper, UT). Because testing was conducted on a soccer field outside, a control test was conducted each trial to help control threats to the validity of the study such as changing weather and the height of the grass.

Immediately after completion of the control run, either static or PNF stretching was performed on the hamstrings, quadriceps, gastrocnemius, and solei. The treatment was reversed for the following trial for a counterbalanced experiment. At the completion of the stretching session, the participants immediately completed a second run through the Balsom agility test with the soccer ball.

PNF stretching was performed using the hold-relax method according to published guidelines (3). Briefly, the stretch consisted of 10 seconds of a passive pre-stretch to a point of mild discomfort, followed by an isometric contraction for 6 seconds, and finishing with 30 seconds of passive stretching. This pattern of stretching was completed twice on each leg for each muscle group and was performed by the principal investigator who was trained on properly performing this method of stretching. The static stretching was also performed according to published guidelines (3). Briefly, the stretch was held for 30 seconds at a point of mild discomfort. Each stretch was performed twice on each leg for each muscle group.

Statistical analysis

The Statistical Package for the Social Sciences for Windows (SPSS Inc., Chicago, IL, Version 17.0) was used for statistical analysis. A difference score was calculated by subtracting the control run from the treatment run for both stretching conditions. One-way repeated measures analyses of variance (RMANOVA) were utilized to compare the difference scores for the static and PNF conditions as well as the difference between the control and treatment trials within the static and PNF conditions. Statistical significance was set at an alpha of .05 for the analysis.

RESULTS

There were no significant differences between the difference scores for the static and PNF conditions on the Balsom agility test, Wilks' Lambda $F(1, 13) = .21$, $P = .658$. Statistical power for this analysis was .07, and partial eta squared was .02. There were also no significant differences between the static control trial and static treatment trial on the Balsom agility test times, Wilks' Lambda $F(1, 13) = 2.37$, $P = .15$. Statistical power for this analysis was .30, and partial eta squared was .15. Also, no significant differences were found between the PNF control trial and PNF treatment trial on the Balsom agility test, Wilks' Lambda $F(1, 13) = .32$, $P = .583$. Statistical power for this analysis was .08, and partial eta squared was .02. Neither mode of stretching significantly affected performance on the Balsom agility test (see tables 2 and 3).

Table 2. Descriptive Statistics by Condition.

Condition	*M*	*SD*
Static Control	14.06	1.04
Static Treatment	14.41	1.42
PNF Control	14.57	1.57
PNF Treatment	14.73	1.25
Static Difference	.34	.83
PNF Difference	.16	1.04

Note. PNF = Proprioceptive Neuromuscular Facilitation, *M* = Mean, *SD* = Standard Deviation.

DISCUSSION

The purpose of this investigation was to examine the effects of static and PNF stretching on soccer-specific agility performance in male elite youth soccer players. The hypothesis that PNF stretching would produce a greater decrease in agility time with a soccer ball was not supported. A notable finding of this study was that static stretching also did not produce a statistically significant decrement to agility performance.

It was thought that PNF stretching would produce faster agility times because PNF stretching has been shown to produce an increase in musculotendinous unit (MTU) stiffness. Rees et al. (31) found that 4 weeks of PNF stretching contributed to an increase in MTU stiffness with simultaneous gains in ankle joint ROM. Because a stiffer MTU system is linked with improved ability to store and release elastic energy, it was thought that PNF stretching would benefit athletic performance due to reduced contraction time or greater mechanical efficiency (31). A few differences exist between this study and the present study. First, female participants were included in the Rees et al. (31) study whereas in the present study, the participants were male. Also, the present study tested the acute effects of PNF stretching.

The findings from this study indicate there is no statistically significant decrement in agility performance from acute static stretching. Although the majority of existing studies have found static stretching impairs performance, there are also studies that have shown no decrement to performance (5, 18, 30, 32, 38, 41). Training status may mediate the relationship between stretching and performance. Static stretching was not detrimental to high-

Table 3. Raw Agility Times (s) and Difference Scores (s) (Treatment-Control) by Participant

	Static Stretch			PNF Stretch		
Participant	Control	Treatment	Difference	Control	Treatment	Difference
1	12.06	12.15	.09	14.85	14.31	-.54
2	12.18	12.97	.79	15.17	14.80	-.37
3	14.19	13.65	-.54	16.60	17.04	.44
4	12.91	12.96	.05	14.56	16.73	2.17
5	13.51	12.41	-1.10	14.85	15.25	.40
6	14.48	14.40	-.08	12.60	14.01	1.41
7	14.70	14.60	-.10	11.85	12.84	.99
8	14.89	16.88	1.99	13.41	14.74	1.33
9	14.61	15.39	.78	12.51	12.86	.35
10	14.20	15.84	1.64	13.49	13.21	-.28
11	14.24	14.71	.47	16.62	15.12	-1.50
12	15.64	15.96	.32	15.95	15.29	-.66
13	14.91	14.52	-.39	16.26	15.27	-.99
14	14.38	15.26	.88	15.24	14.68	-.56

Note. Negative difference scores indicate faster time in the agility trial following that stretch. PNF = Proprioceptive Neuromuscular Facilitation.

speed performance when included in a warm-up for professional soccer players (21). Competitive male middle distance runners' running economy was found not to be affected by prior static or dynamic stretching (18). Vertical jump, peak torque, and mean isokinetic power were not impaired in trained college-aged women following static or ballistic stretching (9, 37). Some authors have suggested that trained athletes might be less susceptible to stretch-induced performance deficits than untrained individuals (9, 37). Unick et al. (37) suggested that a training effect enhances neuromuscular recovery or other mechanisms that result in a reduced effect from static stretching. The participants in the current study were elite youth soccer players and therefore their training status may be the reason for the lack of performance decrement following static stretching.

Because this was the first study to test PNF's effects on agility performance, it is speculative to say if PNF is beneficial or detrimental to performance. Previous studies using PNF stretching on various performance outcomes have been equivocal. Molacek et al. (28) found that both low- and high-volume PNF and static stretching had no significant acute effect on 1-repetition max bench press in resistance trained collegiate football players. Christensen and Nordstrom (6) found no significant effect on vertical jump performance with warm-up only, dynamic stretching, or PNF stretching. However, a study by Franco et al. (15) found PNF stretching decreased bench press endurance while a low volume of static stretching did not have a significant effect. Church et al. (7) found a decreased vertical jump with PNF stretching and concluded that PNF before vertical jump would be detrimental to performance.

It is apparent that there is still controversy in the literature about PNF stretching's effect on performance. Future research is needed with larger sample sizes of elite youth soccer players to determine if PNF stretching is beneficial or detrimental to soccer performance. Furthermore, studies are needed with female elite soccer players to see if there is a sex difference. It would appear that the sex of the participant would affect the results since women tend to be more flexible (3). Future studies should also address the chronic effects of PNF stretching on agility performance. In conclusion, the results of this study indicate that there was no negative effect on agility performance in elite male youth soccer players following static or PNF stretching.

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