Flexibility responses to different stretching methods in young elite basketball players

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Summary

***Introduction*: The aims of study were: 1) to verify the effectiveness of different stretching methods and training; 2) to compare the effects with only training on the flexibility of joints in basketball players.**
***Methods*: 30 males basketball players (age: 17±1yrs; BMI: 23.4±3.1), divided into 2 groups (15 experimental group - EG - and 15 control group, CG), participated to study. EG performed 5 different stretching method: passive stretching, active stretching, postural protocol, PNF and dynamic stretching. To assess differences (p<0.05) between groups, an ANOVA was applied to anthropometrics characteristic (age; height; weight and BMI) and flexibility performances (leg raise in a supine position; forward trunk bending). ANOVA for repeated measurements was conducted to asses differences in each group with time (i.e., pre-post).**
***Results:* Results showed a variation linked to time (F=21.9; p<0.0001) and an effect of the treatment of the leg raise in a supine position test (F=25.1; p<0.0001). Also in flexion test of trunk, the average values could be linked to time of measurement (F=9.96; p<0.0001) and group (F=8.65; p<0.0001).**
***Conclusion:* The results suggest that a specific different stretching protocol should be used in different part of body to offer performance benefit and decreasing of the incidents of injuries.**
Level of evidence: IV.

KEY WORDS: leg raise test, dynamic stretching, youth.

Introduction

Basketball is a popular sport played worldwide both competitively and recreationally by players of all ages[1-7]. It is a game of body contact that includes efforts, such as, sprints, jumps, and quick stops abilities requiring muscle strength. Basketball players tend to get tighter as the season progresses, especially in the hips, groin, and lower back[8, 9]. This is an effect of the cumulative fatigue caused from intense daily practices and games over the course of several months. The only way they can maintain a maximum level of mobility (and flexibility) is if they make a commitment to do stretching[10].
Stretching can be defined as the act of applying tensile force to lengthen muscles and connective tissues and it is used to enhance the range of motion (ROM) of a joint (flexibility)[11- 13]. Various studies[14,15] showed that it is a contributing factor for physical performance and reduced risks of injury. Despite there are various techniques of stretching, such as static (passive and active), global active (postural or Mezieres), proprioceptive neuromuscular facilitation, and dynamic stretching, are used to acutely (a single stretching exercise for several seconds/minutes), currently available data on the effects of this different stretching methods reported conflicting results. Static stretching (SS) increases ROM[11-13] and may limit strength, maximum force, running velocity, balance or sprint performance, with an average reduction in performance of 3.7%[16]. Studies have shown that acute SS reduced

force production[17]; sprint performance[18,19]; depth jump performance; vertical jump height; long jump distance[20,21]; strength endurance[22]; and balance, reaction, and movement times[23]. Consequently, Dynamic stretching (DS) has a minor effect on flexibility, but may well increase muscular strength with an average improvement in performance of 1.3%[24,25]. The proprioceptive neuromuscular facilitation (PNF) have shown greater improvement in ROM compared to SS in a single session[26-28], while the global postural stretching exercises (GPSE) improve ROM, make movement more fluid and limits functional overuse and muscle-tendinous trauma.

Considering that stretching exercises designed to enhance flexibility are regularly included in training programs and warm-up activities of many athletes[19,29], the objectives of this study were: 1) to verify the effectiveness of different stretching methods and training and 2) to compare the effects with only training on the flexibility of joints in basketball players.

Materials and methods

Participants

The sample was composed of 30 males basketball players (age: 17±1 yrs; height: 181.5±1.5 cm, weight: 77.4±12.5 kg; BMI: 23.4±3.1) divided into 2 groups, each formed by 15 subjects (15 experimental group - EG- and 15 control group -CG-), born between 1998 and 2000.

All subjects were healthy, with no history of musculoskeletal or neurological diseas and agreed to maintain their normal exercise and activity levels throughout the duration of the study.

The nature, purpose and possible risk involved in the study was explained to the subjects (or their parents if they were minors) before receiving their informed written Consent Form for participation.

Experimental procedures

The research project, approved by the Research Ethics Committee of the Bari, used a randomized design to evaluate the effectiveness of combined different stretching methods and training and a control training without any stretching in young basketball players. A sports medicine accredited doctor examined each subjects physically before the beginning of the study, and the following inclusion criteria were used: strength training experience (for at least 2 years); physically active; aged between 15 and 18 years; without clinical problems as testified by medical certificate. Exclusion criteria were: limitations or injury due to strenuous physical work; history of limb injuries; hyper- or hypomobility; smoking habit.

While the control group (CG) didn't perform any stretching exercise, the experimental group (EG) performed stretching session with a duration of 10 minutes, at the end of every training session, twice of week, according to a precise protocol, for 5 months, with a different type of stretching each month. In the first month a protocol of passive SS was made up of two series repeated twice for each side, maintaining the stretching position for 25-30 seconds. In the second month a protocol of active SS was made up of two series repeated twice for each side, maintaining an active stretching position for 25-30 seconds. In the third month a postural protocol was followed. Each stretching session included the first and second Mezieres position maintained for 5 minutes respectively. During the stretching a correct diaframmatic respiration was performed. In the fourth month, PNF was performed: 1) gradual and slow maximum stretching of the muscle; 2) isometric contraction for about 15-20 seconds (in stretching position); 3) relaxing for about 5 seconds; 4) stretching of the previously contracted muscle for at least 30 seconds. In the fifth month DS consisted in stretching the limbs in a controlled and slow way in a certain direction in order to reach the maximum ROM possible[30-32].

For each athlete recruited, the evaluations were carried out immediately after training[30,31]. A 36 cm, 360° goniometer (Yourimage, Turin, Italy) was used, marked in 1° increments, with two adjustable overlapping arms (a stationary arm and a moving arm)[33]. Evaluations were conducted every 30 days (the study lasted 165 days), always in the evening around 6:00 pm. Before the tests, data of relative humidity, room temperature and body temperature of the subjects were noted (temperature: 20 °C; humidity: 70%).

All data were collected by the same physician, who has 12 years of clinical and teaching experience in musculoskeletal disorders. Three measurements were taken and the average was reported.

Anthropometric evaluations

Without shoes and only in light clothes, weight and height were measured using an electronic scale (±0.1 kg) and a fixed stadiometer (±0.1 cm) (Seca 702, Seca GmbH & Co. KG, Hamburg, Germany). Body mass index (BMI) was used to assess weight relative to height and calculated dividing body mass in kilograms by height in squared meters (kg/m^2).

Training programme

All subjects followed the same athletic training programme, three times a week. Each training session consisted of 30 minutes warm-up (5 min of jogging at a comfortable speed; 2 min of SS for the lower limb muscles; and 5 min of shooting, from both sides of the court), isotonic training and balance exercises and of 90 minutes technical-tactical training session with their head coach. In particular, the isotonic training used the leg press and leg extension isotonic machines with the following way: 5 sets of 12 leg press repetitions at 70% of Repetition Maximum (1RM) with 3 min of recovery and 4 sets of 10 leg extension repetitions at 70% of 1RM with 3 min of recovery. After this, balance training was performed: 8 sets of 20 seconds of Swiss ball kneeling hold balancing with 30 seconds of recovery; 6 sets of 20 repetitions of the two-handed chest pass balance exercise with 30 seconds of recovery.

Assessment of flexubility measurement

We administered the following tests in accordance with the literature[34,35]. We carried out the measurements in degrees, in agreement with reliability of centimetres *vs* degrees measurement[36]. After the warm-up, flexibility of the hamstring and trunk were measured goniometrically. As reported by Witvrouw *et al.*[37] previous research has indicated that goniometric measurements are reliable.

Hamstring flexibility was evaluated using a passive straight leg Raise *(Leg raise in a supine position-HT)*. The subject in the supine position raises one leg in the air, while keeping the other stretched out on the floor. The evaluator measures the angle (degrees) of the raised limb to the floor. The flexion measurement was made by placing the stationary arm parallel to the floor and moving the other arm following the limb. Both legs were tested randomly.

In orthostatic position, the subject flexes the torso without knee compensation while trying to touch his toes *(Forward trunk bending -FTB)*. The measurement was made by placing the stationary arm parallel to the limb and the other arm following the torso. It is evaluated the final angle recorded in degrees.

Statistical Analyses

All calculations were performed using the statistical package STATA MP14 for Mac.

Quantitative variables are described as means ± standard deviations, and a 0.05 level of confidence was selected throughout the study. Prior of the analysis the Shapiro-Wilk test was applied to test the normal distribution of the data. To assess differences between groups (EG *vs* CG), an analysis of variance (ANOVA) was applied to anthropometrics characteristic (age; height; weight and BMI) and flexibility performances (Right and Left Leg raise in a supine position test and Forward trunk bending). ANOVA for repeated measurements was conducted to asses differences in each group with time (i.e., pre-post).

To analyse the role of confounding factors and confirm the effects of the stretching program, for each outcome measured at the end of the study; group (EG *vs* CG), age, weight, BMI, and baseline value of the outcome considered were assessed as determining factors. Coef with 95% confidence intervals have been calculated and t-test has been performed.

Cohen's effect sizes (ES)[38] were calculated to provide meaningful analysis for comparisons between groups. Values ES≤0.2, from 0.3 to 0.6, <1.2 and >1.2 were considered trivial, small, moderate and large, respectively.

Results

Means, standard deviations of anthropometric parameters of subjects are shown in Table II.

No statistically significant differences emerged in anthropometric values between the EG and the CG.

Graphs 1 describe the results of the right leg Hamstring test in both groups.

ANOVA for repeated measurements reveals that there is a variation linked to time (F=21.9; p<0.0001), but also that there is an effect of the treatment of the Hamstring test (F=25.1; p<0.0001).

In study group and CG the average values are similar to the Left leg Hamstring test (Graphs 2) with variations linked to time (F=21.1; p<0.0001) and to treatment (F=25.4; p<0.0001).

Also in Flexion test of trunk (Graphs 3)**,** the average values could be linked to time of measurement (F=9.96; p<0.0001) and group (F=8.65; p<0.0001).

The multiple regression models highlighted:

- The right leg Hamstring test result at the end of the study depends on the baseline value (Coef 1.01; t=9.9; p<0.0001) and treatment (Coef=20.4; t=8.4; p<0.001);
- The left leg Hamstring test result at the end of the study depends on the baseline value (Coef 0.83; t=7.1; p<0.0001) and treatment (Coef=20.8; t=6.9; p<0.001);
- The Forward trunk bending test result at the end of the study depends on the age (coef=1.35; t=2.6; p=0.015), baseline value (Coef=0.88; t=14.5; p<0.0001) and treatment (Coef=-3.9; t=4.9; p<0.0001);

Discussion

The aim of the present study is to examine the effect of combined different stretching methods on flexibility in adolescent elite basketball players.

To our knowledge, this is the first randomized, controlled trial to assess the effect of a protocol of combined stretching exercises on the flexibility of young professional basketball players. The main results of this study showed that the sequential programme of different stretching exercises in basketball allow improvement over the time of muscle flexibility of the legs and torso. This finding is consistent with previous studies that have reported significant improvement after stretching[8,39,40].

Among the various stretching techniques that are used today to improve flexibility, the most popular amongst male and female athletes and trainers is the SS technique[41,42], because it is carried out very easily[42,43], and it presents a decreased risk of injury[44]. Compared to no stretching, performance after SS was not significantly different in 10-m sprinting, vertical jump height, and agility, while SS provided an improvement in 20-m sprinting[45].

Annino *et al.*[46] evaluated the effects of SS and DS on the vertical jumping before, during and at the end of the training session in 10 elite professional basketball. Their results showed a significant decrease in the Counter Movement Jump test when carried out after the SS session.

Faigenbaum *et al.*[20] reported that there was no significant difference between SS and DS on agility, while Amiri-Khorasani *et al.*[47] showed significant differences in acceleration and speed after DS, compared with those after SS. McMillian *et al.*[48] reported that

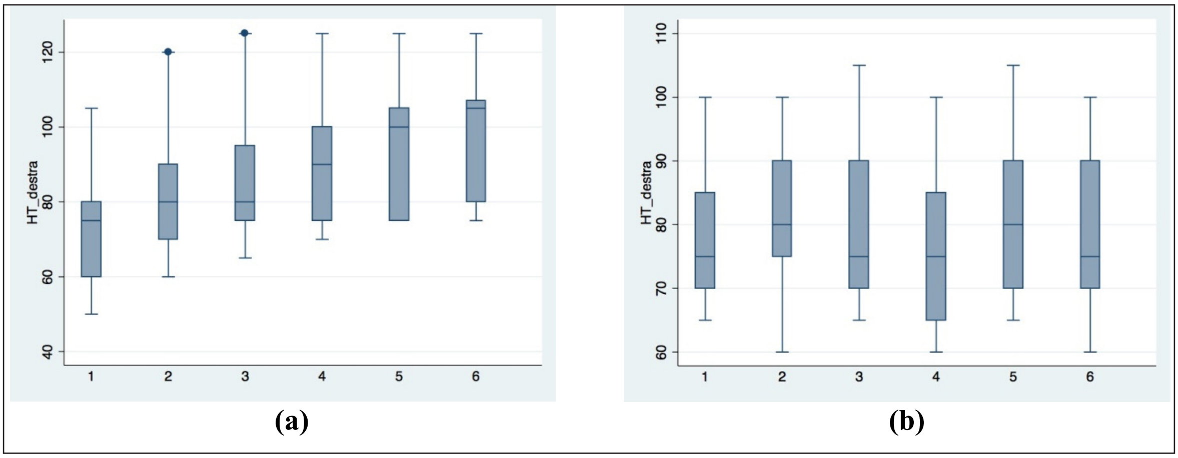
Table I. Specific description of the stretching exercise protocol.

Methods	Muscles involved	Description
Passive Static Stretching	paravertebral	From the sitting position with the lying loose and united limbs, try to approach the hands to own feet while the assistant flips the movement with the hands resting beside the spine in the dorsal.
	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 remained upright with the legs extended and the hands on the hips. with the help of an assistant, during exhalation he flexes the front knee at a 90 degree angle while keeping the extended back knee
	Quadriceps	The subject slightly flexed the support leg. An assistant grabs the raised foot with one hand and pulls the heel to the buttocks
	Hip Adductors	The subject is sitting on the floor with knees bent so that the feet are touched before putting their elbows on the inner thighs. An assistant pushes her legs toward the floor during exhalation
Active Static Stretching	paravertebral	From the sitting position with the lying loose and united limbs, try to approach the hands to own feet.
	Hip extensors	The subject flexed the hip, by raising the knee toward the chest. 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
Postural protocol according to Mezieres positions		First position: The subject is in a supine position elevating the legs to 90 degrees. Second position: the subject is sitting with a straight back at 90 degrees with respect to the legs, elongated in front of him.
PNF	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
	Gluteus	Subject is lying on her back with her knees bent and feet on the floor. It supports the ankle on the controlateral knee, then grabs the back of the thigh with his hands, brings the leg to the chest, holding the position.
	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

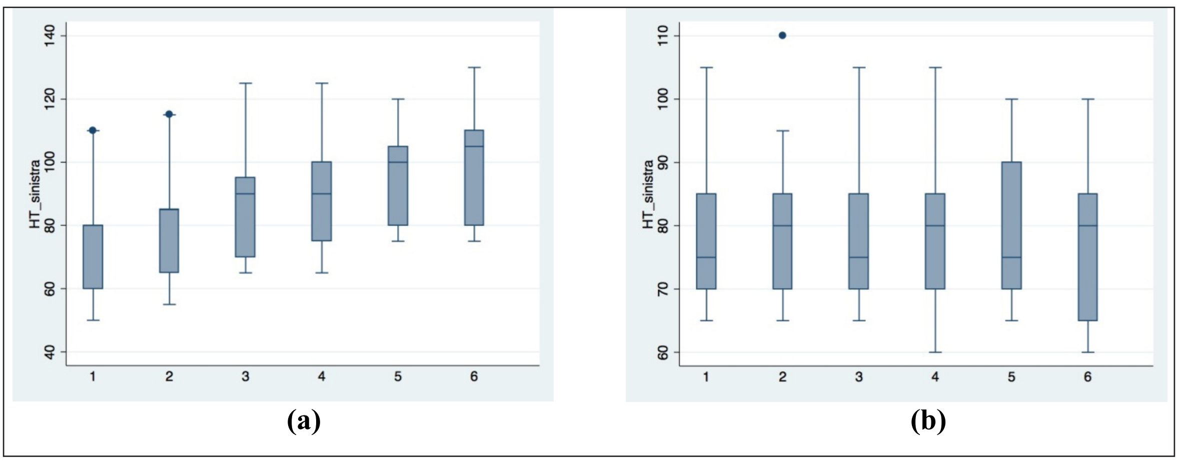
To be continued

Continue from **Table I.**

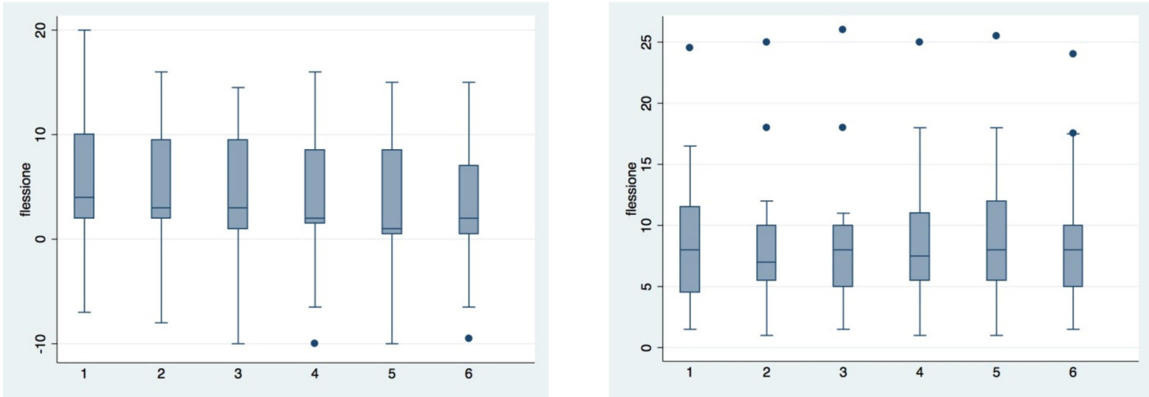
Dynamic stretching	Gastrocnemius	First, the subject raised one foot from the floor and fully extended the knee. Then, he intentionally contracted the dorsiflexors to point the foot upwards
	Hamstrings	From a standing position with both legs straight, the subject contracted the hip flexors to swing the 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



Graph 1. Variations linked to time and to treatment of the right leg hamstring test in the experimental group (a) and in control group (b).



Graph 2. Variations linked to time and to treatment of the left leg hamstring test in the experimental group (a) and in control group (b).



Graph 3. Variations linked to time and to treatment of the torso flexion test in the experimental group (a) and in control group (b).

Table 2. Means, standard deviations of anthropometric parameters of subjects.

	Experimental group (n=15)			Control group (n=15)		
	Mean	±	*Dev. St.*	*Mean*	±	*Dev. St.*
Age (yrs)	17.10	±	0.74	16.70	±	0.80
Weight (kg)	81.10	±	9.50	73.70	±	14.30
Height (cm)	182.90	±	7.20	180.10	±	9.70
BMI (kg/m^2)	24.20	±	1.90	22.70	±	3.90

*P=<0,05

Table III. Means ± standard deviations (SD) of test results of control group (CG) and experimental group (EG).

Time	Right leg hamstring test						Left leg hamstring test						Torso flexion test					
	EG			*CG*			*EG*			*CG*			*EG*			*CG*		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
1	73.6	±	13.8	78.3	±	11.0	74.1	±	16.2	79.0	±	11.7	5.6	±	7.3	9.3	±	6.0
2	81.0	±	14.8	80.1	±	10.5	79.7	±	15.5	80.5	±	11.8	4.2	±	6.7	9.0	±	5.8
3	85.7	±	16.6	78.7	±	11.7	86.3	±	16.1	77.6	±	11.0	3.4	±	6.9	9.0	±	6.0
4	89.5	±	15.2	76.9	±	12.1	89.1	±	16.5	80.3	±	12.4	3.3	±	7.1	9.3	±	6.1
5	93.7	±	15.5	80.9	±	12.2	93.3	±	14.1	80.1	±	10.9	2.9	±	6.8	9.4	±	6.0
6	95.9	±	15.5	79.0	±	11.8	96.4	±	16.5	78.3	±	12.6	2.7	±	6.6	9.1	±	5.5

there was no significant difference as regard agility between acute effect of SS and no stretching. Costa e Silva et al.[49] found no statistical difference between static and PNF stretching protocols (acute effect of different stretching methods on isometric muscle strength). Conversely, various studies[50,51] examined the gain in flexibility after using different stretching methods and have suggested the PNF as the most effective to increase the range of motion when compared with the SS.

In this study, we have found better values in CG than EG after passive static stretching in Right and left Leg raise in a supine position test. Anyway, in right and left test, the DS protocol showed higher values than the other methods in both EC and CG but it reported higher different percentage (14 and 16%, respectively) between groups. In Forward trunk bending, CG had higher values than EG in each stretching methods.

The novelty of this study is having tested the efficacy of a continuous (progressive) combined protocol of 5 different stretching techniques for basketball players. Our results verified the efficacy of stretching sessions in basketball. Our work focuses more on results obtained and maintained over time than on the immediate results of the performance. In fact, we verified that the improvement in flexibility obtained with stretching persists. This result is very important in a sport such as basketball in which the articular mobility is not a primary focus of the training sessions[30].

Understandably, our study was subject to a number of limitations. First, the basketball players were not all blind to the intervention. Second, the population was not very large. Third, this study did not evaluate sports performance in relation to the practice of stretching. Fourth, the study lacks comparison with other stretching techniques protocols. Fifth, it was not verified whether changing the order of the various stretching methods modifies effects. For these reasons, further study is recommended to ascertain the effect of protocol of combined different stretching methods on flexibility in young elite basketball players.

On the basis of our findings, we can recommend a DS to increase the flexibility of hamstring muscles, while a postural protocol to increase the flexibility of trunk. Considering that basketball requiring flexibility, power and agility, the results suggest that a specific different stretching protocol should be used in different parts of body to offer performance benefit and decreasing of the incidents of injuries.

Conflicts of interest

The Authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Ethics

The Authors declare that this research was conducted following basic ethical aspects and international standards as required by the journal and recently update in[52].

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