Original Article

Effects of static stretching duration on isokinetic peak torque in basketball players in semi-professional male basketball players.

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Abstract

The purpose of this study was to investigate the effects of static stretching duration on isokinetic peak torque output at low and high angular velocities in basketball players. Sixteen basketball players, aged 21.8 ± 1.2 years old, of the same training level, participated in the study. The athletes performed randomly, on different days, two static stretching protocols with a total duration of 15 s ($3 \times 5''$) and 2.5 min ($30 \times 5''$) each. Range of motion (ROM) was determined by knee and hip flexion with the use of a goniometer. The isokinetic dynamometer Cybex Norm was used to evaluate the peak torque of the knee extensors and flexors of the dominant leg of each participant at 3 angular velocities (30, 180, 240°s^{-1}). The results showed a positive effect of joint mobility during knee and hip flexing after applying both stretching protocols. Furthermore, a negative effect was observed on the torque output of both knee extensors ($p < .00$) and flexors ($p = <.00$) only when the 2.5 min static stretching exercises were applied. The findings suggest that long-duration static stretching decreases the torque production of knee muscles. Thus, strength and conditioning professionals should consider applying shorter-duration static stretching protocols to avoid any torque reduction.

Key words: static stretching, stretching duration, isokinetic strength, basketball.

Introduction

Flexibility is the ability of one or more joints to preserve their range of motion. It is widely accepted that shortened antagonistic muscles of a joint or a series of joints can affect the body stature or the shape of the limbs' movements (American College of Sports Medicine, 1995).

Passive or static flexibility is the maximal possible range of motion of a joint that an athlete can achieve as an effect of either external forces or his own strength while stretching the antagonist muscles (Harre, 1976). Passive or static stretching includes a determined fixed period during which a muscle is under maximal stretching.

Till now static stretching during warm-up was the classic procedure for preparing human organism before exercise or athletic events (Beaulieu, 1981). The improvement of flexibility (augmentation of the range of motion of a joint) contributes to enhanced performance (Smith, 1994) and to the reduction or the prevention of injuries which are possible when the muscles are shortened (Safran et al., 1989, Smith, 1994). Athletes usually stretch statically each muscle group for a few seconds during warm-up. However, recent studies have reported a reduction of muscle strength after static stretching (Marek et al. 2005, Cramer et al. 2004, Nelson et al. 2001, Kokkonen et al. 1998).

Cramer et al. (2004) and Nelson et al. (2001) used four different static stretching exercises for a total time of 15-16 min in order to stretch the quadriceps of the preferred leg and reported reductions in muscle strength. Behm et al. (2001) also used five different static stretching exercises for the quadriceps which lasted more than 20 min.

Fowles et al. (2000) used interval passive stretching in a sample of ten people in order to examine its effect on the maximal isometric strength production of dorsi flexors. The applied stretching protocol lasted 135 s per muscle group; 125 s of continuous stretching without pain plus 10 s stretching with intense muscle pain after a 5-s interval. Thirteen stretching periods were conducted which lasted 33 min. Results showed a reduction of the maximal isometric strength of these muscle groups and also a reduction of EMG activity.

Power et al. (2004) examined the acute effect of static stretching on the range of motion and on the maximal isometric strength immediately after stretching, 30, 60, 90 and 120 min after the stretching program. The stretching lasted 270 s per muscle group and it was performed until the pain limit was reached. The joint mobility was increased 10% immediately after stretching and remained 8% increased after 30 min, 7% after 60 min and 6% after 90 and 120 min. Maximal isometric strength reduced immediately after stretching and remained reduced (10.4%) after 120 min.

Nelson et al. (2001) examined the acute effect of static stretching on isokinetic torque. Each participant performed two programs. The first program included no static stretching while the second included 15 min static stretching prior to the evaluation of isokinetic torque of knee extensors at various angular velocities. The stretching program included three types of stretching exercises. Each type was performed 4 times 30 sec each time seconds (s), until the pain limit was reached, with an interval of 20s in between. The results revealed a reduction on knee extensors' isokinetic torque only at the slow angular velocities after stretching.

Cramer et al., (2004), reported torque reduction either at a slow (60°s^{-1}) or a fast (240°s^{-1}) angular velocity. Similar results were reported by Marek et al., (2005), after 17 min static stretching and PNF (contraction-relaxation-stretching).

On the contrary, 45s of routine static stretching which is commonly used by athlete's prior training or athletic events showed no reduction of squat jump performance (Knudson et al., 2001).

Zakas et al. (2006) examined the effect of 30s, 5 min and 8 min static stretching on isokinetic torque at slow and fast angular velocities and found a reduction on the knee extensors' isokinetic torque at both slow and fast velocities after 5 and 8 min stretching but no effect of 30s static stretching on torque exertion. The authors concluded that isokinetic torque production is probably affected by the duration of the preceded static stretching.

Some researchers have suggested the avoidance of static stretching during warm up (Cornwell et al. 2001; Nelson et al., 2001; Kokkonen et al. 1998). This recommendation should be accepted under consideration as torque reduction was observed only after long lasting static stretching and not after short lasting static stretching which is commonly used prior to training or events.

Therefore, the aim of the study was to examine the effect of the duration of static stretching on isokinetic torque at slow and fast angular velocities in basketball athletes the present study was designed to investigate whether short lasting static stretching, as it is commonly used by basketball players prior to training or a competitive game, causes a reduction of their isokinetic torque.

Methods

Participants

Sixteen basketball athletes aged 21.8 ± 1.2 , of similar training level, volunteered to participate in the study. They were all healthy without any injury of the lower limbs. The evaluation was performed in the middle of the competitive season in order to ensure the best performance.

After each stretching protocol, participants performed isokinetic knee extensions and flexions on the isokinetic dynamometer Cybex Norm at slow, medium and fast angular velocities of 30, 180, 240°s^{-1} . Goniometer Myrin (Lic Rehab. 17183 Solna, Sweden) was used for the evaluation of the hip and knee flexion mobility of the preferred leg, according to the method of Ekstrand et al. (1982). The study was conducted in accordance to the rules and regulation of the research Ethics Committee of the Aristotle University of Thessaloniki, Greece.

Procedure-Evaluation

Participants performed randomly two different stretching protocols, a week apart. One protocol included three 5s stretching exercises ($3 \times 5''$) and the other included thirty 5s static stretching exercises ($30 \times 5''$). Firstly, the participants were familiarized with the testing procedures. Then the joint mobility of hip and knee flexion of each participant was evaluated from both supine and prone position. Afterwards, participants performed three maximal isokinetic knee extensions and flexions of their preferred leg at 3 different angular velocities. The isokinetic torque and the joint mobility were evaluated twice, once prior each stretching protocol (initial evaluation) and once immediately after it (final evaluation). The participants lied in a prone position on a medical bed for the evaluation of the knee flexion mobility. The Myrin goniometer was placed 5 cm above the ankle, on the anatomical axis of the exterior side of the tibia and the gravity indicator was placed at null indication. The investigator moved passively the tibia to the hip encouraging the participant to relax. The second knee flexion was assessed from the supine position. The goniometer was placed 5cm above the patella on the anatomical axis of the lateral epicondyle of the femur and the greater trochanter and the gravity indicator was placed at null indication. Then, the investigator raised the erected limb. During the measurement the participant remained relaxed and the evaluation was performed by the investigator. The range of knee flexion of the dominant leg was measured. All measurements, prior and after the stretching programs, took place at the same time of the day without prior warm up exercises. None of the participants took part in any training session 24 hours prior to testing procedures.

Measurement of isokinetic torque

Isokinetic torque was measured from the seated position on Cybex Norm isokinetic dynamometer at the angular velocities of 30, 180 και 240°s^{-1} . All participants performed three trial knee extensions and flexions at each angular velocity, they rested for three minutes and they then performed three maximal knee extensions and flexions at each angular velocity. Rest between velocities was 30s. The best effort, according to the highest torque, was used for the statistical analysis. Gravity correction was performed according to the Cybex recommendations.

Intervention program

Each participant lied on a medical bed for 5 min in order to relax. Then the hip and knee flexion was measured. Immediately after that, the participant cycled for 5 min on a cyclometer at low intensity (50W) to warm up the muscles of the lower limbs. After the warm up, the isokinetic torque of the knee extensors and flexors was evaluated (first test). Then, the stretching protocol took place (3 x 5'' or 30 x 5''). After the static stretching exercises, the joint mobility was evaluated again and immediately afterwards the second evaluation of the isokinetic torque took place.

Stretching protocol

The first protocol of static stretching was performed for the dominant limb and included three trials which lasted 5s each (3 x 5'') and the second protocol included 30 trials which lasted 5s (30 x 5''). Rest between trials was 10s for both protocols.

At the first protocol each participant performed unassisted standing static stretching on the knee extensors of the dominant leg. The subjects stood upright with the hand against a wall for balance and flexed the knee at 90°. Then they grasped the ankle with the hand and fully flexed the knee joint until the heel touched the buttock and then extended the hip joint. The participants remained there for 5s and they felt the elongation of the knee extensor. At the end of the 5s effort, the limb returned to its anatomical place and the participants relaxed for 10s.

For the static stretching of the knee flexors the participants stood upright. They extended the dominant limb in front of them with the sole planted on the ground while the other leg was flexed at the knee and hip and the sole of the foot was also planted firmly on the ground for balance. The participants flexed forward at the hip while the hands tended to touch the toes of the extended limb until a hamstring stretch was perceived, and then remained there for 5s. After the 5s stretching, the limb returned to its anatomical place and relaxed for 10s before the next trial.

The second protocol was implemented in the same manner as the first one but it included 30 efforts (total duration 2,5 min).

Statistical analysis

Results are presented as the mean $\pm$ SD. Two-way (protocol x time) ANOVA with repeated measures on time was applied for each dependent variable. Significant interactions were followed by simple main effect analysis in order to identify significant pairwise differences. The level of significance was set at $\alpha = 0.05$.

Results

ANOVA showed that there was no statistically significant effect of the type of protocol on knee extensors' isokinetic torque in 30°/s ($p > .05$). However, there was a significant effect of time $F_{(1,14)} = 33.285$, $p < .001$ and a significant interaction of protocol x time $F_{(1,14)} = 24.714$, $p < .001$. After the long protocol, knee extensors' scores were lower than the pre-protocol scores ($p < .001$).

No statistically significant effect of the type of protocol or interaction of protocol x time, on knee extensors' isokinetic torque in 180°/s, was found ($p > .05$) while a significant effect of time was found $F_{(1,14)} = 24.116$, $p < .001$. Both post-protocol scores were lower than the pre-protocol scores ($p > .05$).

No statistically significant effect of the type of protocol on knee extensors' isokinetic torque in 240°/s was found ($p > .05$). However, a significant effect of time $F_{(1,14)} = 13.478$, $p < .001$ and a significant interaction of protocol x time was found $F_{(1,14)} = 23.748$, $p < .001$. After the long protocol, knee extensors' scores were lower than the pre-protocol scores ($p < .001$).

The type of protocol had no statistically significant effect on knee flexors' score in 30°/s ($p > .05$). A significant effect of time $F_{(1,14)} = 70.359$, $p < .001$ and a significant interaction of protocol x time $F_{(1,14)} = 131.250$, $p < .001$, was found. After the long protocol, knee extensors' scores decreased compared to the pre-protocol scores ($p < .001$).

A significant effect of time $F_{(1,14)} = 39.434$, $p < .001$ and a significant interaction of protocol x time, $F_{(1,14)} = 39.434$, $p < .001$, was found on knee flexors' isokinetic torque in 180°/s while no effect of the type of protocol was found ($p > .05$). The long protocol had a negative effect on knee flexors' scores as post-protocol scores were lower than pre-protocol scores ($p < .001$).

The type of protocol had no statistically significant effect on knee flexors' score in 240°/s ($p > .05$). A significant effect of time $F_{(1,14)} = 25.375$, $p < .001$ and a significant interaction of protocol x time $F_{(1,14)} = 72.917$, $p < .001$, was found. After the long protocol, a reduction of the knee flexors' scores in 240°/s was observed ($p < .001$).

A significant effect of time $F_{(1,14)} = 4825.713$, $p < .001$ was found on knee extensors' as both post-protocol scores increased significantly compared to the pre-protocol scores. No other significant effect or interaction was found.

A significant effect of time $F_{(1,15)} = 24.002$, $p < .001$ was found on knee flexors' as both post-protocol scores decreased significantly compared to the pre-protocol scores. No other significant effect or interaction was found.

Table 1. Range of motion in basketball players initially and immediately after the flexibility training sessions of different stretch conditions. Mean values are presented in degrees $\pm$ SD.

	Stretching protocol (3x5'')		Stretching protocol (30x5'')	
	pre	post	pre	post
Knee flexion ($^{\circ}$)	145.2 $\pm$ 4.7	152.9 $\pm$ 4.4 ^a	144.5 $\pm$ 4.5	153.2 $\pm$ 4.1 ^a
Hip extension ($^{\circ}$)	78.2 $\pm$ 3.4	85.2 $\pm$ 3.7 ^a	78.73.5 $\pm$	85.2 $\pm$ 3.7 ^a

^aPost-stretching mean was significantly greater than the pre-stretching mean at $P < 0.001$ in both protocols.

Table 2. Isokinetic peak torque (mean $\pm$ SD) before and after the stretching protocols for the movement angular velocities 30, 180, 240 $^{\circ}$ s⁻¹.

Angular velocity ($^{\circ}$ s ⁻¹).	Stretching protocol (3x5'')				Stretching protocol (30x5'')			
	Knee extension		Knee flexion		Knee extension		Knee flexion	
	pre	post	pre	post	pre	post	pre	post
30	265.9 $\pm$ 23.9	263.1 $\pm$ 23.4	178.8 $\pm$ 23.4	178.2 $\pm$ 23.7	268.0 $\pm$ 21.6	250.3 $\pm$ 21.5 ^a	183.5 $\pm$ 26.4	172.9 $\pm$ 26.7 ^a
180	177.5 $\pm$ 6.3	174.26.1	118.5 $\pm$ 14.0	118.8 $\pm$ 16.0	181.7 $\pm$ 7.3	174.1 $\pm$ 6.6 ^a	124.3 $\pm$ 11.7	115.2 $\pm$ 12.2 ^a
240	151.7 $\pm$ 24.6	149.9 $\pm$ 27.4	100.7 $\pm$ 8.8	101.8 $\pm$ 9.9	152.2 $\pm$ 25.3	143.5 $\pm$ 25.4 ^a	105.5 $\pm$ 9.7	96.6 $\pm$ 11.5 ^a

^aPost-stretching mean was significantly greater than the pre-stretching mean at $P < 0.001$ in the long stretching protocol.

Discussion

Static stretching is widely used by athletes and especially basketball athletes during warm up prior to training or athletic events. The present results showed that the range of motion of hip and knee joint is improved after a static stretching protocol either of short (not longer than 15s) or long (2,5 min) duration. The present results are consistent with similar surveys implemented on stretching exercises of various durations. (Zakas et al. 2002, Fredrick & Szymanski 2001, Hedrick 2000, Madding, Wong, Hallum, et al. 1987).

Additionally, 15s static stretching had no negative effect on isokinetic torque production of knee extensors and flexors at slow and fast angular velocities while 3 min static stretching had a negative effect on torque production of the same muscle groups at all tested angular velocities.

The current results are in accordance with those reported by Zakas et al. (2006) and are in line with other studies, although they have used different methods (Knudson et al. 2001, Power et al. 2004). Zakas et al. (2006) found no significant negative effect of 30s static stretching on the isokinetic torque at slow (60 $^{\circ}$ και 90 $^{\circ}$ s⁻¹) and fast (210 $^{\circ}$ και 270 $^{\circ}$ s⁻¹) angular velocities.

Knudson et al. (2001) also found no significant reduction of squat jump performance after a 45s (3 x 15'') static stretching protocol. Power et al. (2004) reported similar results, although they used a longer stretching protocol (6 x 45'').

Torque reduction observed after the 3 min protocol was also previously reported by Zakas et al. (2006) after 5 and 8 min protocols and by Power et al. (2004) after a 4,5 min static stretching protocol. While relevant reductions in torque output after static stretching were also reported by other researchers (Cramer et al., 2004, Nelson et al., 2001, Fowles et al., 2000, Kokkonen et al., 1998).

Long lasting static stretching seems to affect negatively the isokinetic torque only at slow angular velocities but not at fast velocities (Nelson et al., 2001a). This conclusion was doubted by Cramer et al. (2004) who found torque reduction at both slow (60 $^{\circ}$ s⁻¹), and fast (240 $^{\circ}$ s⁻¹) angular velocities after a 16 min stretching protocol and concluded that torque reduction is an effect of the type of stretching (static) and not an effect of velocity.

The present results agree with those of Cramer et al. (2004) and Zakas et al. (2006) as torque was reduced at both slow and fast angular velocities after a 3 min static stretching protocol. Although static stretching is a crucial part of warm up prior to training or athletic events, some writers suggest avoiding it (Cornwell et al. 2001, Nelson et al. 2001, Kokkonen et al. 1998) as its appliance affects negatively torque and power production. This recommendation confuses both coaches and athletes who do not know if they should use static stretching or not. In fact these results were found only after protocols which lasted more than 10min.

Prolonged static stretching is not commonly used by athletes and especially basketball athletes during warm up. The previously mentioned studies took place in laboratory conditions and no aerobic submaximal efforts were performed. Athletes usually combine static stretching with submaximal aerobic exercises. Young and Behm (2003) used 4min dynamic active warm up prior to 1min static stretching and static stretching without aerobic warm up and found squat jump reduction only when stretching was performed without aerobic warm up. The authors concluded that the aerobic warm up prior to static stretching reduces the negative effects of static stretching on power movements such as squat jump. However, the combination of aerobic warm up and static stretching and its effect on torque and power production need further investigation.

Other authors have reported that torque reduction is due to the reduction of stiffness of musculotendinous systems (Kokkonen et al., 1998; Nelson et al., 2001; Cornwell 2001) or neuronal inhibition (Behm et al., 2001; Fowles et al. 2000). Muscle tissue damage is another possible explanation of the reduction of performance (Shrier, 2004). Prolonged static stretching can increase muscle tissue damage as it was proved by the increased level of creatine kinase (CK) in blood (Smith et al. 1993).

However, the exact mechanism responsible for torque reduction after prolonged static stretching is not yet determined. Thus further investigation is needed to determine it.

Conclusion

Many athletes spend enough time to stretch the muscles before training or a game. The results of the current study indicate that 15s stretching may be effective for flexibility without causing any reduction on knee extensors' and flexors' isokinetic torque at low, medium and high angular velocities. These results may be useful for athletes and basketball coaches as they will make them realize which warm-up activities are the most effective for performance.

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