PRINT: ISSN 0972-0073 ONLINE: ISSN 2456-6802
Anthropologist, 21(30: 500-504 (2015)
DOI: 10.31901/24566802.2015/21.03.14

Acute Effects of PNF Stretching on Maximum Voluntary Contraction in Men

Asim Cengiz[1], Bilal Demirhan[2], Cetin Yaman[3] and Metin Yaman[4]

[1]Middle East Technical University, Turkey
[2]Ondokuz Mayis University, Samsun, Turkey
[3]Sakarya University, Department of Physical Education and Sports, Sakarya, Turkey
[4]Gazi University, Department of Physical Education and Sports, Ankara, Turkey
E-mail: [1]<acengiz@studentsussa.edu>, [2]<bilaldemirhan55@gmail.com>, [3]<cyaman@hotmail.com>, [4]<myaman@yahoo.com>

KEYWORDS Dominant, Peak Torque, Extension, Flexion, Nondominant

ABSTRACT This study aimed to investigate the influence of PNF stretching on the peak torque (PT) isokinetic leg extension PT at 60^0 and $180^{0 \cdot s^{-1}}$ in the stretched and unstretched limbs. Twelve college male athletes who were enrolled in a fitness class volunteered to participate in the study. Pre and post PNF stretching exercises isokinetic PT for extension and flexion of the dominant and non-dominant limbs were measured. There was a decrease in the PT for both extension and flexion between the pre- and post-stretching conditions. The reductions in PT experienced in the present study tentatively support the hypothesis that stretching may change the length-tension association.

INTRODUCTION

Stretching is frequently performed before exercise (Adamo et al. 2000) and athletic events (Beaulieu 1981; Young and Behm 2002). Conventionally, it is assumed that escalating joint range of motion will support superior performance (Roelants et al. 2004) and decrease the risk of injury during vigorous exercise (Smith 1994). Earlier studies (Young and Behm 2002; Roelants et al. 2004; Smith 1994; Holcomb 2000; Mcneal and Sands 2001; Nelson et al. 2001; Wallin et al. 1985) concluded that stretching depresses maximal force production.

Stretching techniques (static, PNF, dynamic) are considered to increase muscular flexibility to advance range of motion (Cengiz 2015), and help prevent harm in daily life or sports, lessen muscle soreness, and progress muscle potential, and muscular performance (Lim et al. 2014). However, it has been anticipated that static stretching (SS) is related with a reduction in neural input into the muscles. Therefore, it is likely that acute impact of stretching on muscle strength may influence the outcomes of many treatment and conditioning exercises. PNF stretching is also a typical form of stretching. These exercises frequently used in both athletic and clinical settings to augment both active and passive range of motion (ROM) in order to optimize motor performance and treatment (Yuktasir and Kaya 2009). Many studies have indicated that PNF stretching produces a superior improvement in ROM (Etnyre and Abraham 1986; Ferber et al. 2002; Funk et al. 2003; Magnusson et al. 1996).

Although several studies have assessed the effect of PNF stretching on increased ROM (Decicco and Fisher 2005; Sheard and Paine 2010; Yuktasir and Kaya 2009) and vertical jump performance (Bradley et al. 2007; Christensen and Nordstrom 2008), controversial results were existed about the effects of PNF stretching on strength and power. For example, on study reported that no significant differences were observed in jump performances between the PNF stretching and control conditions (Miyahara et al. 2013)]. Also, the findings of another study indicated that none of the stretching procedures caused a decline in knee extension power (Manoel et al. 2008). Yet, some studies found performance decrements after PNF stretching. For instance, a study found PNF stretching reduced bench press endurance while a low volume of SS did not change any outcome (Fowles 2008). In Place et al. (2013) study, the two minutes of PNF stretching did not influence squat jump and countermovement jump outcomes.

The lack of studies on isokinetic strength is quite surprising because trainers commonly use that PNF before or during the recovery after athletic events. Knowledge pertaining to the effects of PNF's effect on performance is considered necessary to verify whether PNF is useful in improving performance in sports that require high levels of peak torque. It was concluded that there were minimal effects of PNF stretching on the unstretched limb. The authors hypothesized that if the stretching-induced reduction in force production were the result of a central nervous system (CNS) mechanism, the unstretched as well as stretched limb would be likely affected (Avela 1999). To further analyze this hypothesis, the present study examined the effects of PNF stretching on the PT during concentric, isokinetic leg extension PT at 60^0 and $180^{0 \cdot s-1}$ in the stretched and unstretched limbs.

Objectives of the Study

This study was intended to investigate the PT of the stretched and unstretched leg extensor and flexor muscles in recreationally active men. It was predicted that PNF would cause a decrease in peak torque of the participants in both dominant and nondominant limbs for extensors and flexors.

MATERIAL AND METHODS

Experimental Approach to the Problem

Twelve collegiate male athletes who were enrolled in a fitness class, (age, 24.25± 2.56 years; body mass, 69.96± 8.86 kg; height, 172.15 ± 3.6 cm) volunteered to participate in the study. The subjects were healthy and indicated no previous or current knee-, hip- or ankle-related injuries and no noticeable limits in knee ROM. The local ethic committee approved the study and all subjects filled questionnaire informed consent forms prior to testing.

Experimental Design

Isokinetic PT for values for extension and flexion of the dominant and nondominant limbs were measured before and after PNF stretching. The measurements were taken using an (Cybex 6000 dynamometer (CYBEX Division of LUMEX, Inc., Ronkonkoma, New York) isokinetic dynamometer. The leg extensor and leg flexor muscle of dominant leg were measured velocities of 60^0 $^{s-1}$ and $180^{0 \cdot s-1}$ presented in randomized order. Each subject was permitted 5 trials before starting the test.

PNF Stretching

PNF stretching was completed using the hold-relax technique according to published guidelines (Beaulieu 1981). In brief, the stretch included of thirty seconds of a passive prestretch to the point of mild discomfort, continued by an isometric contraction for six seconds, and concluding with thirty seconds of passive stretching. An expert investigator aided the stretching. ANOVA and paired-samples **t**-tests were used to analyze the data.

RESULTS

There was a decrease in the PT for both extension and flexion (Table 1) from pre- to post stretching all conditions. The PT was decreased for both extension (139. 25 ±31.96 vs. 136.80 ± 29.07) and flexion (79.41 ±19.60 vs. 75.83 ±21.5) in dominant limps after PNF stretching at $60^{0\ s-1}$. There were also similar reductions at $180^{0 \cdot s-1}$. For nondominant limps, there were also decreases in PT for extension (147.75 ±37.5 vs. 144.41 ±37.69) and flexion (86.58 ±18.87 vs. 79.16 ±21.31) at $60^{0\ s-1}$. There were also decreases in PT for flexion (79.58 ±11.68 vs.73.58 ±14.14) and extension (110.08 ±26.79 vs.105.25 ±26.41) at $180^{0 \cdot s-1}$ for nondominant limps.

DISCUSSION

It has been anticipated that stretching is related with a reduction in neural input into the

Table 1: The mean and standard deviation values for PT flexion and extension at pre- and post stretching.

Variable	*Pre-PNF*				*Post-PNF*			
	Dominant Leg		*Nondominant Leg*		*Dominant Leg*		*Nondominant Leg*	
	60° s-1	*180°. s-1*	*60° s-1*	*180°. s-1*	*60°.s-1*	*180°. s-1*	*60° s-1*	*180°. s-1*
Peak Torque Extensor (Nm) (Mean, SD)	39.25 ±31.96	99.91 ±26.56	147.75 ±37.5	110.08 ±26.79	*136.80 ± 29.07	*92.83 ±27.80	*144.41 ±37.69	*105.25 ±26.41
Peak Torque Flexor (Nm) (Mean, SD)	79.41 ±19.60	75.08 ±13.91	86.58 ±18.87	79.58 ±11.68	*75.83 ±21.5	*68.41 ±16.93	*79.16 ±21.31	*73.58 ±14.14

Table 2: Comparison of conditions

Variable	*Condition*	*T value*	*P value*
Extension $60^{0 \cdot s-1}$	Dominant (Pre-PNF vs Post-PNF)	-2.061	0.064
	Nondominant (Pre-PNF vs Post-PNF)	-2.759	*0.019
Extension $180^{0 \cdot s-1}$	Dominant (Pre-PNF vs Post-PNF)	-3.766	*0.003
	Nondominant (Pre-PNF vs Post-PNF)	-3.664	*0.004
Flexion $60^{0 \cdot s-1}$	Dominant (Pre-PNF vs Post-PNF)	-3.493	*0.005
	Nondominant (Pre-PNF vs Post-PNF)	-5.536	*0
Flexion $180^{0 \cdot s-1}$	Dominant (Pre-PNF vs Post-PNF)	-5.698	*0
	Nondominant (Pre-PNF vs Post-PNF)	-2.855	*0.016

muscles and resulted in acute reductions in performance. Two major hypotheses were reported for the cause of the stretching-induced reductions in muscular force–producing capacity: (1) mechanical factors, such as changes in the viscoelastic properties of the musculotendinous unit and (2) neurologic factors, such as reduced motor unit activation (Marek et al. 2005). The purpose of this study was to test these hypotheses and to find out the effects of PNF stretching on the PT, isokinetic leg extension PT at $60^{0\ s-1}$ and $180^{0 \cdot s-1}$ in the stretched and unstretched limbs. The results of the study indicated that there was a decrease in the PT for both extension and flexion (Table 1) from pre- to post stretching. Furthermore, the PT was greater at $60^{0\ s-1}$than at $180^{0 \cdot s-1}$.

Previous studies that have evaluated the impact of PNF stretching on many performance outcomes have indicated inconsistent outcomes. For example, one study reported that no significant differences were observed in jump performances between the PNF stretching and control conditions (Miyahara et al. 2013). Another study indicated there were not any differences in the influence of warm up only, dynamic stretching, or PNF stretching on vertical jump heights (Christensen and Nordstrom 2008). Also, in another study, the acute effects of static, dynamic, and PNF on peak muscle power output in women. Concentric knee extension power was assessed isokinetically at $60° \cdot s^{-1}$ and $180° \cdot s^{-1}$ in twelve active women. The findings of the study concluded knee extension power was not declined for all the protocols and the results recommend that dynamic stretching may augment acute muscular power to a better point than static and PNF stretching (Manoel 2008). However, other studies have found performance decrements after PNF stretching. For instance, one study found that PNF stretching decreased bench press endurance while a low intensity of static stretching did not have a significant effect (Fowles 2000). Another study observed a decrease in vertical jump height after PNF stretching (Church et al. 2001), similar study indicated that vertical jump heights subsequent to PNF stretching were inferior than following the static stretching and/or control conditions (Yuktasir and Kaya 2009). In contrast, another group (Young and Elliott 2001) showed there was not any major in jump heights between the PNF stretching and control groups. These inconsistent consequences (Yuktasir and Kaya 2009; Young and Elliott 2001) may have been the outcome of the differences among the stretching protocols and/ or the types of jumping tests performed (Marek et al. 2005) suggesting that the degree of the performance decrease may be in direct amount to the amount of the stretching exercises (Fowles 2000). It is therefore likely that either the extent of the stretching or fatigue may have affected the vertical jumping capability (Marek et al. 2005) or isokinetic knee extension evaluated in these preceding studies (Table 2).

The present study indicated that there were decreases in PT for both extension and flexion following PNF stretching. Previous reports indicated similar results (Miyahara et al. 2013; Marek et al. 2005). However, the findings of the current study are unique in demonstrating decreases in muscle strength in both extension and flexion conditions as a result of the PNF stretching exercises. Nevertheless, the results of this study extend the findings of previous studies (Yuktasir and Kaya 2009; Young and Elliott 2001) and recommend that PNF stretching decrease the force producing abilities of the leg extensors and flexors during MVC concentric isokinetic muscle actions at $60^{0\ s-1}$ and $180^{0 \cdot s-1}$. Similar findings have been observed in some other studies. For example, one study indicated reductions in PT, MP, and EMG amplitude as a consequence of both static and PNF stretching (Bradley 2007). Another study evaluated the effects of PNF stretching and static stretching on the MVC. These results suggested that the PNF stretching and SS reduced the maximal isometric strength.

Also recent studies indicated controversial results about the effects of PNF on strength. Keese et al. (2013) found that preceding PNF stretching did not decrease number of repetitions performed in multiple sets of the leg curl. Therefore, it was recommended that a modest level of PNF could be used prior to resistance exercise with a minimum depressing effect. Higgs et al. (2009) investigated if three weeks of PNF stretching training could effectively augment the knee flexion range of motion without having an unfavorable outcome on the peak isokinetic torque of the quadriceps. Reis et al. (2013) aimed to examine and evaluate the effects of PNF and SS on MVC and EMG activity in indoor soccer players. The findings of the study confirmed that PNF or SS techniques induced no decline on MVC and muscle EMG activity in indoor soccer players. It is likely, thus, that either the amount of the stretching or fatigue may have affected the vertical jumping abilities or isokinetic knee extension subsequent to the PNF stretching conducted in previous studies (Marek et al. 2005).

It was reported that previous studies have recommended that the angle-torque relationship during MVC muscle actions may offer information concerning the length-tension association of the muscle fibers. It is likely, thus, that stretching-induced changes in the length-tension association may be manifested through alterations in the angle-torque affiliation (Marek et al. 2005).

CONCLUSION

In the present study, the PT decreased for for both extension and flexion between pre- and post PNF stretching. Concerning the mechanisms causing the stretching-induced performance deficit, the reductions in PT experienced in the present study tentatively support the hypothesis that stretching may change the length-tension association.

RECOMMENDATIONS

The outcomes of this study have implications for sports facilitators and men who execute PNF stretching prior to performance actions. Further studies are considered necessary to detect the essential mechanisms that impact the time course of stretching-induced reductions in MVC for active and inactive population of various ages.

REFERENCES

Adamo DE, Martin BJ, Johnson PW 2000. Vibration induced muscle fatigue, a possible contribution to musculoskeletal injury. *Eur J Appl Physiol*, 88: 134–40.

Avela J, Kyrolailan H, Komi PV 1999. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. *J Appl Physiol*, 86: 1283–1292.

Beaulieu JE 1981. Developing a stretching program. *Phys Sports Med*, 9: 9–66.

Bradley PS, Olsen PD, Portas MD 2007. The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *J Strength Cond Res*, 21(1): 223-226.

Cengiz A 2015. EMG and peak force responses to PNF stretching and the relationship between stretching-iinduced force deficits and bilateral deficits. *J Phys Ther Sci*, 26(3).

Christensen BK, Nordstrom BJ 2008. The effects of proprioceptive neuromuscular facilitation and dynamic stretching techniques on vertical jump performance. *J Strength Cond Re,* 22(6): 1826-1831.

Church JB, Wiggins MS, Moode FM, Crist R 2001. Effect of warm-up and flexibility treatments on vertical jump performance. *J Strength Cond Res*, 15: 332–336.

Decicco PV, Fisher MM 2005. The effects of proprioceptive neuromuscular facilitation stretching on shoulder range of motion in overhand athletes. *J Sports Med Phys Fitness*, 45(2): 183-185.

Etnyre BR, Abraham LD 1986. Gains in range of ankle dorsiflexion using three popular stretching techniques. *Am J Phys Med,* 65(4): 189-196.

Ferber R, Osternig L, Gravelle D 2002. Effect of PNF stretch techniques on knee flexor muscle EMG activity in older adults. *J Electromyogr Kinesiol*, 12(5): 391-397.

Fowles JR, Sale DG, MacDougall JD 2000. Reduced strength after passive stretch of the human plantarflexors. *J Appl Physiol*, 89: 1179–1188.

Funk DC, Swank AM, Mikla BM, Fagan TA, Farr BK 2003. Impact of prior exercise on hamstring flexibility: a comparison of proprioceptive neuromuscular facilitation and static stretching. *J Strength Cond Res,* 17(3): 489-492.

Higgs F, Winter SL 2009. The effect of a four-week proprioceptive neuromuscular facilitation stretching program on isokinetic torque production. *J Strength Cond* Res, 23: 1442-1447.

Holcomb WR 2000. *Stretching and Warm-up*. Champaign, IL: Human Kinetics pp. 321-342.

Keese F, Farinatti P, Massaferri R 2013. Acute effect of proprioceptive neuromuscular facilitation stretching on the number of repetitions performed during a multiple set resistance exercise protocol. *J Strength Cond Res*, 27(11): 3028-3032.

Lim KI, Nam HC, Jung KS 2014. Effects on hamstring muscle extensibility, muscle activity, and balanceof different stretching techniques. *J Phys Ther Sci*, 26: 209–213.

Manoel ME, Harris-Love MO, Danoff JV, Miller TA 2008. Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. *J Strength Cond Res*, 22(5): 1528-1534.

Marek SM, Cramer JT, Fincher AL, Massey LL, Dangelmaier SM, Purkayastha S, Fitz KA, Culbertson JY 2005. Acute effects of static and proprioceptive neuromuscular facilitation stretching on muscle strength and power output. *J Athl Train*, 40: 94-103.

Magnusson SP, Simonsen EB, Aagaard, P, Dyhre-Poulsen P, McHugh MP, Kjaer M 1996. Mechanical and physical responses to stretching with and without preisometric contraction in human skeletal muscle. *Arch Phys Med Rehabil*, 77(4): 373-378.

Mcneal JR, Sands WA 2001. Static stretching reduces power production in gymnasts. *Technique*, (Nov/Dec): 5–6.

Miyahara Y, Naito H, Ogura Y Katamoto S, Aoki J 2013. Effects of proprioceptive neuromuscular facilitation stretching and static stretching on maximal voluntary contraction. *J Strength Cond Res*, 27(1): 195–201.

Nelson AG, Allen JD, Cornwell A, Kokkonen J 2001. Inhibition of maximal voluntary isometric torque production by acute stretching is joint-angle specific. *Res Q Exerc Sport*, 72: 68–70.

Nelson AG, Guillory IK, Cornwell C, Kokkonen J 2001. Inhibition of maximal voluntary isokinetic torque production following stretching is velocity-specific. *J Strength Cond Res*, 15: 241–246.

Place N, Blum Y, Armand S 2013. Effects of a short proprioceptive neuromuscular facilitation stretching bout on quadriceps neuromuscular function, flexibility, and vertical jump performance. *J Strength Cond Res*, 27(2): 463-470

Reis EF, Pereira GB, de Sousa NM 2013. Acute effects of proprioceptive neuromuscular facilitation and static stretching on maximal voluntary contraction and muscle electromyographical activity in indoor soccer players. *Physiol Funct Imaging (England*), 33(6): 418-422.

Sheard PW, Paine TJ 2010. Optimal contraction intensity during proprioceptive neuromuscular facilitation for maximal increase of range of motion. *J Strength Cond Res*, 24(2): 416-421.

Roelants M, Delecluse C, Verschueren SM 2004. Whole-body-vibration training increases knee-extension strength and speed of movement in older women. *J Am Geriatr Soc*, 52: 901–908.

Smith CA 1994. The warm-up procedure: To stretch or not to stretch—a brief review. *J Orthop Sports Phys Ther*, 19: 12–17.

Yuktasir B, Kaya F 2009. Investigation into the long-term effects of static and PNF stretching exercises on range of motion and jump performance. *J Body Mov Ther,* 13(1): 11-21.

Wallin D, Ekblom B, Grahn R, Nordenborg T 1985. Improvement of muscle flexibility: A comparison between two techniques. *Am J Sports Med,* 13(4): 263-268.

Yuktasir B, Kaya F 2009. Investigation into the long-term effects of static and PNF stretching exercises on range of motion and jump performance. *J Body Mov Ther,* 13(1): 11-21.

Young W, Elliott S 2001. Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching, and maximum voluntary contractions on explosive force production and jumping performance. *Res Q Exerc Sport*, 72: 273–279.

Young WB, Behm DG 2002. Should static stretching be used during a warm-up for strength and power activities? *Strength Cond. J*, 24: 33–37.