Original Paper

Biomedical Human Kinetics, 2, 1 - 4, 2010

DOI: 10.2478/v10101-010-0001-2

Acute effect of the proprioceptive neuromuscular facilitation method on vertical jump performance

Carlos J. Nogueira [1,3], Leonardo A. dos Santos Galdino [2,3], Rodrigo G. de Souza Vale [3], Danielli B. de Mello [3,5], Estélio H. M. Dantas [1,3,4]

[1] Castelo Branco University (UCB), Rio de Janeiro; [2] Faculty of Estácio de Sá, Juiz de Fora; [3]Human Motricity Biosciences Laboratory (LABIMH), Rio de Janeiro; [4]Invited Research of University of Valencia, Spain; [5] Physical Education and Exercise College (ESEFEX), Rio de Janeiro, Brazil

Summary

Study aim: To assess the acute effect of the proprioceptive neuromuscular facilitation method (PNF) on the explosive strength of lower extremities of male soldiers.
Material and methods: A group of 26 male soldiers performed two exercise sessions on different days, in a random order: without stretching (control exercise) or by applying PNF (experimental exercise). Before and after the PNF (0, 10, 20, 40 and 60 min), 3 vertical counter-movement jumps on a tensometric platform were executed.
Results: CMJ results in the experimental sessions were significantly ($p<0.001$) decreased after the PNF exertion in relation to the initial (pre-session) value. No significant post-session decreases were found in the control exercise. However, the differences between the experimental and control results were significant ($p<0.05$) only immediately after the PNF exertion and 10 min later.
Conclusion: The PNF method negatively affects the vertical jump performance and, thus, ought not to be used as part of warm-ups.

Key words: Stretching – Proprioceptive neuromuscular facilitation – Vertical jump

Introduction

Flexibility exercises are commonly used as a warm-up in sports and other physical activities in order to prevent lesions or improve the performance [1,12,13,15,19, 20,21]. In flexibility training, the static, dynamic or proprioceptive neuromuscular facilitation (PNF) techniques are used [4,11]. These techniques can be executed with a submaximal intensity (stretching), when the work is geared to maintain flexibility and for movements of normal range below the level of muscular discomfort, and maximal (flexing), used to improve the flexibility by forcing a greater range of movement, above the discomfort threshold [18].

The reports on the acute effects of the techniques used in flexibility training on strength are controversial [1,17]. When flexing is used before activities involving jumps, a negative effect on explosive strength and performance of the vertical and drop jumps was noted [7,10]. As in those studies mainly the static method was used, little information could be found regarding the effects of the PNF method in relation to the jumps. Church *et al.* [6] and Bradley *et al.* [1] noted a significant reduction in the vertical jump performance after PNF. However, other authors did not report significant PNF-induced decreases in muscle performance in activities involving maximal muscular contraction, explosive strength and jumping [14,21]. This prompted us to investigate into that issue, i.e. into the effects of PNF on explosive strength, especially with regards to vertical jump abilities, in order to gather information which would enable teachers, coaches, physical instructors and physiotherapists to better orient their students, athletes and patients. Thus, the objective of this study was to verify the effects of the PNF method on explosive strength of lower extremities in male soldiers.

Material and Methods

Subjects: A group of 26 soldiers aged 21.0 ± 1.4 years volunteered to participate in the study. Their body height was 175 ± 0.9 cm and body mass 65.8 ± 3.5 kg. All subjects

Author's address Prof. Carlos José Nogueira, Rua Esperanto,185, São Miguel, Santos Dumont, Cep 36240-000, Minas Gerais, Brazil carlosjn29@yahoo.com.br

practiced regular physical activities at least 3 times a week, two hours a day, for at least a year. To participate in the study, the subjects had to be injury-free, able to perform the tests and specific training, as well as presenting negative responses to all the questions asked in the physical activity readiness questionnaire (PAR-Q) [16]. The questionnaire was validated as a tool for screening adults who may exercise only upon medical consent. The volunteers were informed of study objective and protocol and were instructed to avoid intense physical activity for 24 h before starting the training sessions. All subjects signed their written consents complying with the binding rules and the study was approved by the local Human Research Ethics Committee.

Methodology: A preliminary session was held, each subject executing three jumps to get familiar with the procedure. Two procedures were used: without flexibility exertions (control exercise) or with flexibility exertions using the PNF method. These procedures were applied on separate days, at least 48 h apart, in a random order. Each subject performed 3 vertical counter-movement jumps before, immediately after the exercise, and 10, 20 40 and 60 min later. In every case, the best result was recorded. Before every session a 10-min submaximal warm-up was applied (60 – 70% of HRmax) on a cycle ergometer (Movement, Brazil). The jumps were performed on a tensometric platform (Kit Multisprint / Hidrofit, Brazil) with the use of Multisprint 1.20 software [10].

The experimental exercise consisted of 3 vertical jumps followed by hip flexion movements with knees extended in supine position and supine flexing of the ankle, the subject in supine position, and of flexing the knee, the subject in prone position (PNF exercise) [10]. The PNF protocol consisted of four series of exertions in which the muscles were contracted isometrically for 5 s and sustained, motionless, for 30 s in the movement position (beyond the discomfort threshold) [13]. The series were spaced by 20-s intervals, the entire PNF exertion lasting 10 min. Immediately after the PNF, as well as 10, 20, 40, and 60 min later, jump test was repeated. The PNF sessions were monitored by applying the Perceived Exertion in Flexibility Scale (PERFLEX) [8]. The scale ranged from 0 to 110 and was categorised into 5 verbal descriptions. The control exercise consisted of 3 vertical jumps without the use of PNF and after a 10-min interval corresponding to the duration of the PNF exertion, and 10, 20, 40 and 60 min later, the test was repeated.

Data analysis: After having checked the normality (by Shapiro-Wilk's test) and homogeneity of variances (by Levene's test) of the data, the ANOVA for repeated measures was applied within groups and followed by the Tukey's *post hoc* test. The SPSS (14.0 for Windows) software was used in data analysis, the value of $p \leq 0.05$ being considered significant.

Results

Average exercise intensity, as determined by the PERFLEX scale, was 70.1 ± 0.5, i.e. near maximum. The results of counter-movement jumps performed during the control and experimental sessions are presented in Figs. 1 and 2, and the relationship between the observed and predicted values in Fig. 3.

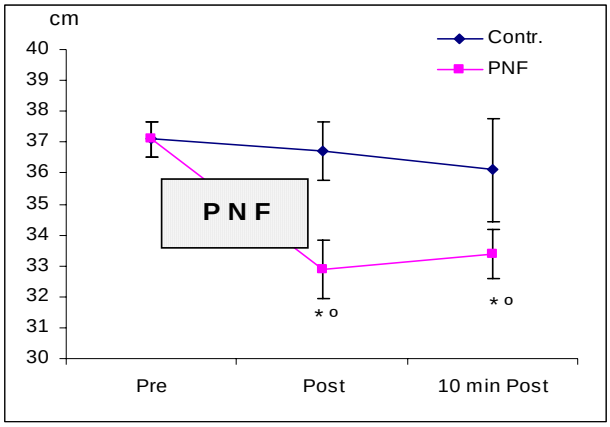

Fig. 1. Mean heights (±SE) of counter-movement jumps in the control and exercise (PNF method) sessions

Legend: Contr. – Control exercise; PNF – Experimental exercise, preceded by proprioceptive neuromuscular facilitation exertion; * Significantly ($p<0.001$) lower from the pre-session value; ^{o} Significantly ($p<0.05$) lower from the respective control value

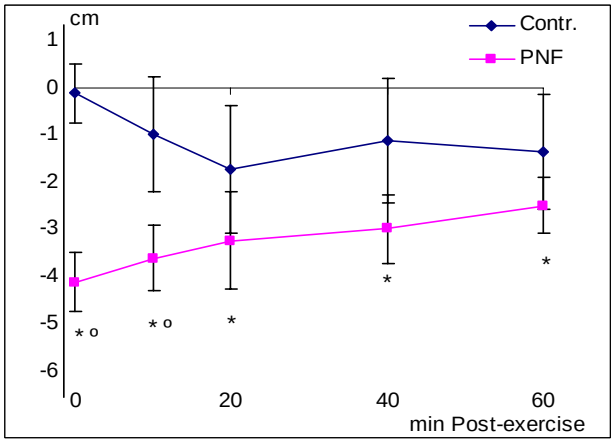

Fig. 2. Mean differences (±SE) between the post- vs. pre-session values of counter-movement jumps in the control and exercise (PNF method) sessions

Legend: Contr. – Control exercise; PNF – Experimental exercise, preceded by proprioceptive neuromuscular facilitation exertion; * Significantly ($p<0.001$) lower from the pre-session value; ^{o} Significantly ($p<0.05$) lower from the respective control value

The results presented in Fig. 1 indicated significant ($p<0.05$) decreases in CMJ height in the experimental exercise, i.e. immediately after and 10 min after the PNF exertion compared with the initial value. No such decreases were noted in the control exercise, in which no PNF exertion was applied. As follows from Figure 2, which shows post-pre differences, the differences observed in the control and experimental sessions are significant only up to 10 min post-session, as shown also in Fig. 1, and then tend to converge.

Discussion

The obtained results show a significant worsening of the vertical jump performance following a 10-min PNF exertion and this effect persisted for up to 10 min as compared with control jumps not preceded by such an exertion. Similar results were reported by Marek *et al.* [13], who studied the effects of static stretching techniques and PNF on the strength of the quadriceps muscle and found decreases in peak muscle torque, mean strength and in the amplitude of the EMG signal for both protocols used. Also Brentano *et al.* [2] found a reduction in maximum muscle torque of knee flexors in 10 trained men following the PNF "hold-relax" technique. It is to be emphasised that the reduction of muscle strength brought about by stretching exertions do not depend on the recorded strength variable.

Christensen and Nordstrom [5] presented contradicting results; they reported that the use of maximal dynamic stretching and PNF as a warm-up applied to a group of 68 men and women, combined with activities like jogging preceding vertical jumps, did not significantly affect the performance. It is important to point out that combining PNF with jogging probably induced a large increase in the extensibility of contracted tissues, brought about by the aerobic warm-up, thus positively influencing the execution of vertical jumps. A deeper insight into this question in future studies is called for in order to assess the effects of warm-ups combining flexibility exercises with other activities (jogging, running, exercises with weight) preceding physical and sporting activities.

Young and Elliot [21], upon comparing the acute effects of maximal static stretching and PNF on the explosive strength and vertical jump performance, noted a reduction averaging 3.2%. Carvalho *et al.* [3] verified the acute effects of submaximal static exertions and of the PNF technique on the vertical jump performance by 9 young tennis players of both sexes, and found no significant changes, PNF stretching resulting in a slight drop (by 4.6%) in the jump height. In this study, that reduction amounted to about 10% but our and the abovementioned studies used different techniques, like the drop jump and jumps without counter-movement, and were performed by subjects experienced in vertical jumps.

Church *et al.* [6] noted a significant decrease in the vertical jump performance in 40 female athletes, the majority of whom practiced jumping activities, after applying PNF loads to the *quadriceps* and posterior thigh musculature. They found, however, no drops in jumping performance following static stretching or in the control group, thus confirming our observations on the negative effects of PNF on vertical jumps.

The significant decrease in the jumping performance in this study lasted for up to 60 min post-PNF when related to the pre-PNF level and up to 10 min when related to the control jumps. Bradley *et al.* [1] noted a drop in the performance of CMJ (by 5.1%) in 18 male university students following a PNF "contract-relax" session, maximal static stretching and dynamic stretching, the jumps being performed immediately after and 5, 15, 30, 45 and 60 min post-exertion, the decreases at 0 and 5 min post-exertion being significant, and the values returned to the pre-exertion level 15 min after all kinds of exertions. In another study [10], that decrease lasted up to 30 min following a static stretching session in 21 male and female volunteers. That prolonged negative effect of PNF exertions speaks against applying such exertions as an element of warm-ups.

Inasmuch possible mechanisms of negative effects of PNF exertions on jumping performance were not investigated by us, numerous studies attribute them to a reduced rigidity of the muscular-tendon unit [2,9,19], alterations in the sensitive reflex and a decreased activation of the musculature involved [9]. Besides, Bradley *et al.* [1] attributed a greater decrease in the vertical jump induced by PNF than by maximal static stretching to an additional effect of the reciprocal and autogenous inhibition in neural excitability.

Summing up, the use of PNF exertions significantly worsened the vertical jump performance for at least 10 min post-stretching. That technique ought thus not to be used before activities requiring explosive strength of lower extremities like the vertical jump. It is suggested that this method be used in training sessions in which the objective is to increate flexibility and not in warm-up sessions. However, future studies will be needed with variations in the volume and intensity of use of different flexibility techniques in different populations (athletes and non-athletes).

References

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

2. Brentano M.A., L.P.Rodrigues, L.F.M.Kruel (2008) Efeitos de diferentes sessões de aquecimento no torque e amplitude articular de homens jovens. *Revista Brasileira de Educação Física e Esportes* 22:53-62.

3. Carvalho F.L.P., J.E.L.R.Prati, M.C.G.A.Carvalho, E.H.M. Dantas (2009) Acute effect of static stretching and proprioceptive neuromuscular facilitation on the performance of vertical jump in adolescent tennis players. *Fitness Perform.J.* 8:264-268. DOI:10.3900/fpj.8.4.264.e

4. Chagas M.H.,E.L.Bhering, J.C.Bergamini, H.J.Menzel (2007) Comparação de duas diferentes intensidades de aplicação de alongamento na amplitude de movimento. *Revista Brasileira de Medicina do Esporte*.14:99-103.

5. Christensen B.K., B.J.Nordstrom (2008) The effects of proprioceptive neuromuscular facilitation and dynamic stretching techniques on vertical jump performance. *J.Strength Cond. Res*. 22:1826-1831. DOI: 10.1519/JSC.0b013e31817ae316

6. Church J.B, M.S.Wiggins, E.M.Moode, R.Crist (2001) Effect of warm-up and flexibility treatments on vertical jump performance. *J.Strength Cond.Res*.15:332-336.

7. Cornwell A., A.G.Nelson, B.Sidaway (2002) Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. *Eur.J.Appl.Physiol*. 86:428-434.

8. Dantas E.H.M, P.T.Salomão, R.G.S.Vale, A.Achour Jr., R.Simão, N.M.A.Figueiredo (2008) Escala de esforço percebido na flexibilidade (PERFLEX): um instrumento adimensional para se avaliar a intensidade? *Fitness Perform.J*. 7:289-294. doi:10.3900/fpj.7.5.289.p

9. Fowles J.R., G.Sale,J. D.Macdougall (2000)Reduced strength after passive stretch of the human plantar flexors. *J.Appl.Physiol*. 89:1179-1188.

10. Galdino L.A.S., C.J.Nogueira, E.P.César, M.E.P.Fortes, J.R.Perrout, E.H.M.Dantas (2005). Comparação entre Níveis de Força Explosiva de Membros Inferiores antes e apost Flexionamento Passivo. *Fitness Perform.J*. 4:11-15.

11. Gama Z.A.S., C.A.S.Medeiros, A.V.R.Dantas, T.O.Souza (2007) Influência da freqüência de alongamento utilizando facilitação neuromuscular proprioceptiva na flexibilidade dos músculos isquiotibiais. *Revista Brasileira de Medicina do Esporte*.13:33-38.

12. Little T., A.G.Williams (2006) Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J.Strength Cond.Res*. 20:203-207.

13. Marek S.M., J.T.Cramer, A.L.Fincher, L.L.Massey, S.M. Dangelmaier, S.Purkayastha , K.A.Fitz, J.Y.Culbertson (2005) Acute effects of static and proprioceptive neuromuscular facilitation stretching on muscle strength and power output. *J.Athletic Train*. 40:94-103.

14. Miyahara Y., Y.Ogura, H.Naito, S.Katamoto, J.Aoki (2005) Effect of proprioceptive neuromuscular facilitation stretching and static stretching on maximal voluntary contraction. *Med.Sci.Sports Exerc*. 37(Suppl. 5):S441.

15. Power K., D.Behm, F.Cahill, M.Carroll, W.Young (2004) An acute bout of static stretching: efects on force and jumping performance. *Med.Sci.Sports Exerc*. 36:1389-1396.

16. Thomas S., J.Reading, R.J.Shephard (1992) Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Can. J.Sport Sci*. 17:338-345.

17. Torres J.B., M.C.S.C.Conceição, A.O.Sampaio, E.H.M. Dantas (2009) Acute effects of static stretching on muscle strength. *Biomed.Hum.Kinet.* 1:52-55. DOI: 10.2478/v10101-009-0013-y
http://versita.metapress.com/content/q5378x27r08p/?p=ffadef6e0ce5485985733c6ca0955852&pi=0

18. Varejão R.V., E.H.M.Dantas, S.M.Matsudo (2007) Comparação dos efeitos do alongamento e do flexionamento, ambos passivos, sobre os níveis de flexibilidade, capacidade funcional e qualidade de vida do idoso. *Revista Brasileira de Ciência e Movimento*. 15:87-95.

19. Unick J, H.S.Kieffer, W.Cheesman, A.Feeney (2005) The acute effects of static and ballistic stretching on vertical jump performance in trained women. *J.Strength Cond.Res*. 19:206-212.

20. Yamaguchi T, K.Ishii (2005) Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. *J.Strength Cond.Res*.19:677–683.

21. Young W, S.Elliot (2001) Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching, and maximal voluntary contractions on explosive force production and jumping performance. *Res.Q.Exerc.Sport* 72:273-279.

Received 26.09.2009
Accepted 28.12.2009