PROLONGED EFFECTS OF MODIFIED PNF STRETCH TECHNIQUES ON HIP JOINT FLEXIBILITY

William L. Cornelius[1], Kyle G. Graves[2], and David W. Hill[1]
[1]University of North Texas, Denton, Texas, USA,
[2]University of Texas, Arlington, Texas, USA

INTRODUCTION

Considerable research has focused on ways to improve active range of motion (ROM). Active modified proprioceptive neuromuscular facilitation (PNF) stretching techniques have been reported to be significantly more effective at improving active ROM than conventional stretching techniques (Cornelius, Jensen, & Odell, 1995; Hardy, 1985; Osternig et al., 1990; Prentice, 1983). No significant difference in ROM was found, however, between active PNF techniques (Cornelius et al., 1995).

Stretching is part of many pre-game warm-ups. Some individuals may not begin participation in the actual competitive event for up to a half-hour after stretching. Although ways in which ROM can be improved has been established, there is a paucity of research on the extended effects of an acute PNF flexibility maneuver. It is now appropriate to determine whether the effects of stretching before the beginning of the game would be present after a prolonged rest interval. The primary purpose of this investigation was to determine the effectiveness of maintaining increased levels of flexibility over an extended delay interval.

METHODS

Data Collection

Seventy-five college-age male and female students volunteered to participate in the study. All were free from lower back, hip or leg disabilities. Participants were assigned to one of five treatment groups (each with 15 participants). Two groups performed modified PNF stretching; one group was assigned conventional active stretching (C), and the remaining two groups represented the active and resting control conditions.

Participants performed a five-minute aerobic warm up prior to testing. The experimental session always began with a baseline measure to determine initial hip active flexibility. The participant was then required to perform three trials of the experimental treatment with a one-minute rest interval in between. An active stretch measure was taken at the end of the third trial and recorded for data analysis.

Participants were placed on a testing table in a supine position. The left leg and pelvis were secured to the table by means of adjustable straps. A splint device was placed on the subject's right testing leg to ensure continual knee extension. The pelvis was secured to the table slightly below the iliac crest in order to maintain a neutral pelvic position. A Leighton flexometer was placed at the mid-thigh of the right leg in order to assess hip flexion ROM in degrees. The flexometer has been shown to provide reliable ($r \geq .97$) measures of hip flexion (Leighton, 1942). Consequently, ROM at the right hip joint served as the criterion measure.

A post active stretch measurement was taken at one of three time intervals of 5, 15 and 30 minutes in order to determine the persistence of the effects of the treatments. One of the time intervals was used during each of the lab visits. The Active Control (AC) group performed a moderate intensity walk program throughout the particular time interval before the post active,stretch was measured. This walk was on an indoor walking track at a pace of one-minute per 0.626 km lap (0.10 kmph). The Resting Control (RC) group did not perform any physical activity throughout their prescribed time interval before the post active stretch was assessed.

Three experimental stretching techniques were used. Two were modified PNF techniques (PC and PIC) and one was a conventional active flexibility technique (C). The C technique consisted of a six-second submaximal concentric contraction of the hip flexors in the agonist pattern. Consequently, the hip extensors (target muscles) were placed on a stretch during this unassisted active maneuver. The two PNF stretching techniques began with the experimenter lifting the subject's right leg to full hip flexion, without subject assistance. Hip flexion ROM was determined for all flexibility maneuvers through subject response, indicating stretch had reached a point where tension (not pain) was felt behind the knee at the popliteal fossa. This position in the agonist pattern indicated the end point in hip flexion. For the PC technique, this passive stretch of the target muscle group was followed by a submaximal concentric contraction of the hip flexor muscle group. The PIC technique began with a passive stretch followed by a six-second maximal voluntary isometric contraction of the target muscle group and subsequent six-second submaximal concentric contraction of the hip flexors. This final maneuver was the replication of the baseline protocol.

Data Analysis

To determine if there was a significant acute effect of the intervention, the baseline and immediate-post-treatment values were compared using a two-way ANOVA with repeated measures across time and with participants nested in group (intervention). Each participant had only one measure of ROM at 5, 15, and 30 minutes after the PNF treatment. To determine if there was a significant effect of the different types of stretching treatment on the persistence of improved ROM, different scores were calculated for ROM measured immediately after the treatment, and 5, 15, and 30 minutes after treatment. The immediate-post-treatment score was calculated as the difference between the mean of the three available post-treatment and baseline scores for each individual. The scores for 5, 15, and 30 minutes after treatment used the baseline value obtained at the given session, not the mean of the three baseline values. The three post-treatment scores were compared using a two-way ANOVA with repeated measures across time and with participants nested in group (treatment).

RESULTS

Results of the repeated measures ANOVA revealed a significant ($p < 0.001$) effect of treatment on ROM. Results of post hoc testing revealed that ROM increased immediately after the treatment in the three groups of subjects who performed stretching procedures. The increase in ROM was greater for the PIC group than for the PC and C groups: There was no change in ROM from baseline in either of the control groups. See Table 1.

Table 1. Mean (±SD) values for ROM in degrees of flexion. There were 15 subjects in each group.

Group	Baseline	Immediate-post-treatment	Difference
Active Control	97 ± 9	98 ± 9	1 ± 1[a]
Rest Control	92 ± 12	92 ± 12	0 ± 1[a]
C	86 ± 11	89 ± 11	4 ± 2[b]
PC	87 ± 15	93 ± 15	6 ± 3[b]
PIC	82 ± 12	91 ± 14	9 ± 5[c]

Note: difference scores with similar superscripts were not statistically different

Since there was no change in ROM in the two control groups, further analyses were restricted to data from the three treatment groups. Results of the repeated measures ANOVA performed over the different scores revealed a significant ($p < 0.001$) effect of treatment on ROM. Results of post hoc tests revealed that the differences (i.e., the improvements in ROM) were greater in the three treatment groups than in the two control groups, with the improvement 'in the PIC PNF group significantly greater than the improvement in the PC PNF and the C conventional treatment groups. Further post hoc testing revealed that differences between the groups were evidenced only immediately and five minutes after performance of the stretching treatments. See Table 2 and Figure 1.

Table 2. Mean (±SD) values for differences in ROM (post-treatment value minus baseline value) in degrees. There were 15 subjects in each group.

Group	Time after the PNF Treatment			
	Immediate	5 minutes	15 minutes	30 minutes
C	4 ± 2[a]	1 ± 6[a]	0 ± 4[a]	1 ± 3[a]
PC	6 ± 3[a]	5 ± 4[ab]	1 ± 7[a]	2 ± 3[a]
PIC	9 ± 5[b]	6 ± 4[b]	2 ± 5[a]	3 ± 3[a]

Note: for each period, values with similar superscripts were not statistically different

DISCUSSION

ROM was improved immediately after performance of both the modified PNF techniques and the conventional active stretch technique. The improvement was greater with the PIC technique than with the PC and C techniques. Because the PIC treatment was more effective than the two techniques that did not include an isometric contraction of the target muscle group, our first conclusion was that the isometric contraction (and the Golgi tendon organ reflex that it presumably elicits) is a necessary component of modified PNF stretching if optimal benefits are to be obtained. Regarding the first conclusion, that the maximal voluntary isometric contraction (MVC) of the stretched target muscle is an integral part of modified PNF techniques, other investigations purport that autogenic inhibition elicited from these MVCs is a critical mechanism for decreasing resistance to stretch and for increasing ROM (Cornelius et al., 1995; Hardy, 1985; Prentice, *1983;* Osternig et al., 1990).

Because there was no difference between the results obtained using the PC and C techniques, our second conclusion was that performance of the passive stretch does not contribute to the effectiveness of modified PNF stretching techniques. This implies there is no reflex regulation of the target muscles from the passive stretch. Houk and Henneman (1967) and Jansen and Rudjord (1964) are in agreement with this finding because they indicate the threshold of tendon organs may be lower for muscle contraction than passive stretching maneuvers. This suggests isometric contraction associated with mod ed PNF stretching techniques play a role in stimulating Golgi tendon organs and subsequent reflex regulation of target muscles.

Regardless of which stretching technique was used, the increased ROM persisted less than 15 minutes. The PIC and PC treatments were equally effective (ROM elevated 5 or 6 degrees) after five minutes, although the 5 degree effect for PC was not statistically different from the 1 degree effect for C. Therefore, our third conclusion was that the effects of stretching techniques are short lived (i.e., less than 15 minutes) and appear dependent upon the specific technique that is used. Examination of Figure 1 suggested that the loss of ROM gains was similar among treatments and that the magnitude of the initial gain (i.e., the magnitude of the improvement from baseline to immediate-post-treatment) was the primary determinant of the gain that was apparent after five minutes. That is, initial effect aside, there appeared to be no greater persistence in the benefits of stretching using the different flexibility techniques. While the pattern of response seemed clear (see Figure 1), the large within-treatment variability reduced the likelihood of finding a statistically significant effect. First, our results suggest that the PIC technique is the method of choice when the goal is to increase joint ROM as much as possible (although our results suggest that a PC technique might be equally effective). Second, our results suggest that the improvement in ROM is transient. Therefore, if increased ROM is a factor in performance, PNF must be performed within minutes of the competition. On the other hand, athletes might perform PNF to reduce muscle tension prior to competition; we have no evidence whether such an effect (if there is one) is more persistent than the effect on ROM.

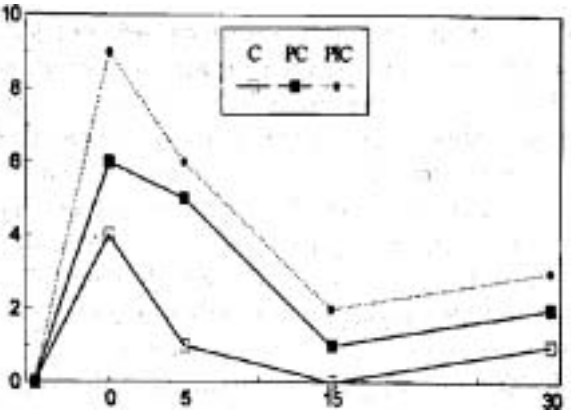

Figure 1. Graphical presentation of the differences in ROM compared to baseline after performance of the three different modified PNF stretching maneuvers.

CONCLUSIONS

There were three conclusions: (1) the maximal voluntary isometric contraction of the stretched target muscle is an integral part of modified PNF techniques, (2) the passive stretch does not contribute to the effectiveness of modified PNF stretching techniques, (3) the effects of stretching techniques are short lived. The practical implication of the findings is that the PIC technique is the most effective way to increase ROM. However, the increase is transient. This suggests that, when increased ROM is important for a sport or activity, PIC stretching must be performed immediately before the activity. Stretching should probably be performed at regular intervals during intermittent sport activities.

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