The Effects of Cold Application and Modified PNF Stretching Techniques on Hip Joint Flexibility in College Males

William L. Cornelius, Khosrow Ebrahim, Jack Watson, and David W. Hill

The purpose of the study was to determine the effects of modified Proprioceptive Neuromuscular Facilitation (PNF) flexibility techniques on hip flexion in college males and to determine if local cold application enhances the effectiveness of these techniques. Male subjects (N = 120), with an average age of 21.5 ± 2.7 years, were randomly assigned to one of four different kinds of stretching treatments with cold or no cold application (15 per group). Range of motion (ROM) in degrees was determined following four stretching techniques: three modified PNF (PCP, 3-PI,CP, 3-PL,CP) and a passive stretch (P). Data were analyzed using a 2 (conditions) x 4 (treatments) ANOVA. There were no significant differences in ROM between cold and no cold conditions. Significant differences existed among ROM techniques (p < .05). Post hoc analyses revealed that the three modified PNF techniques resulted in greater ROM than the passive stretch technique. However, we conclude that cold application does not influence the effectiveness of selected stretching techniques.

Key words: PNF, stretching, cold application, cryotherapy

Cold application has been used as a modality in sports conditioning and rehabilitation. Several studies reported significant increases in joint range of motion (ROM) when a 10-min cold application was incorporated prior to modified Proprioceptive Neuromuscular Facilitation (PNF) stretching techniques (Cornelius & Jackson, 1984; Rosenberg, Cornelius, & Jackson, 1990). Active PNF flexibility techniques were found to be superior to a passive stretch in elderly females, ages 55–84, (Rosenberg et al., 1990) and college males, ages 17–26, (Cornelius & Jackson, 1984). These studies found the active PNF technique, with a 3-s isometric contraction of the stretched muscle (target muscle) and a subsequent concentric contraction of the opposite muscle (PI,CP), superior to the PNF technique without the isometric contraction (PCP) in producing increased ROM at the hip joint. Rosenberg et al. (1990) referred to the flexibility technique, using both the isometric and concentric contractions, as slow-reversal-hold-relax (SRHR), and Cornelius and Jackson (1984) utilized the PI,CP reference.

A 6-s isometric contraction has been established as an effective maneuver in modified PNF stretching techniques (Cornelius & Hinson, 1980; Hardy, 1985; Holt, Travis, & Okita, 1970). As an alternative to the 6-s isometric contraction, a time-saving 3-s maximum voluntary isometric contraction (MVIC) of the hip extensors (antagonist) was introduced as a part of the modified PNF stretching techniques (Cornelius & Hinson, 1980). There was no significant difference between modified PNF stretching techniques using a 3- or 6-s MVIC. It was suggested there may be limitations, however, in using the PNF stretching techniques when the stretched muscle (antagonist) is traumatized. Consequently, the PCP stretching technique was considered as an alternative because an active stretch of the target muscle is facilitated by a concentric contraction of the opposite (agonist) muscle group. The agonist contraction results in relaxation of the antagonist due to reciprocal inhibition (Guyton, 1991, p. 598). Modified PNF stretching techniques, with a concentric contraction of the agonist used subsequent to a MVIC of the antagonist, have produced significant main effects over conventional techniques, such as passive, ballistic, and static stretching (Cornelius & Hinson, 1980; Cornelius & Rauschuber, 1987; Etnyre & Abraham, 1986a; Prentice, 1983; Rosenberg et al., 1990). However, no study has examined the effects of an isometric contraction of the agonist on ROM in the agonist pattern. The agonist pattern is in the direction of the stretching maneuver. Consequently, the purpose of this study was to determine the efficacy of particular modified PNF flexibility techniques under two conditions, cold and no cold application to the mid posterior thigh.
Method

Subjects

The sample for the study consisted of 120 males from physical education classes in the Department of Kinesiology, Health Promotion, and Recreation at the University of North Texas. Criteria for inclusion in the study were that subjects be free from injury or disability to the hip and legs, have not selected kinesiology as a major or minor field of study, not be a member of an intercollegiate athletic team, and have a body fat percentage of 18% or less. Subjects meeting all selection criteria were invited to participate in the study on a voluntary basis. The investigation met guidelines set by the Human Subjects Review Board of the University of North Texas.

Procedures

Subjects were asked to report to the laboratory wearing unrestrictive clothing. Voluntary, written, informed consent was secured, and general information was obtained including age, gender, weight, height, and body fat percentage. Body fat percentage was established from skinfold thickness at the chest, abdomen, and thigh using the nomogram of Baun, Baun, and Raven (1981).

Subjects were randomly assigned to one of eight groups. Each group performed a different treatment by modality (cold or no cold). Subjects under the cold condition received 10 min of cold application in the supine lying position, consisting of ice cubes in a 1-gallon plastic bag, placed on the posterior thigh (Knight, 1978, p.57). Cold application was applied immediately prior to data collection. McMaster, Liddle, and Waugh (1978) found the ice bag to be more efficient, more economical, and safer than frozen gel, chemical ice envelope, or refrigerant inflated bladder cold modalities.

The leg under study was the dominant leg, determined by asking each subject to kick a ball before actual testing began. Each subject assumed a relaxed, supine position on a flat table with the arms at the sides during flexibility testing. The nondominant leg was secured to the table by a strap applied at the mid-thigh to eliminate movements other than those required of the subject during testing.

Subjects were given three trials in one of four stretching treatments with either a cold or no cold application. A 2-min rest was given between trials (Santomier, 1971). All measures were taken at a terminal position of hip flexion.

Stretching Techniques

The first and last maneuver for each treatment trial was a passive stretch of the hip extensors. Passive hip flexion was performed in these maneuvers to a point where tension or slight discomfort was felt at the popliteal fossa at the posterior knee. The knee was held in full extension throughout the maneuvers with assistance provided by the investigator. A hand was placed at the distal end of the anterior thigh to control knee joint flexion.

One of the four techniques was used on each group. The first technique (P) was a passive stretch in the agonist pattern (hip flexion). A second technique (PCP) consisted of three steps: a passive stretch of the hip extensors, an active stretch facilitated by a concentric contraction of the hip flexors, and a passive stretch of the hip extensors. All three steps in the second technique were in the agonist pattern. The third technique (SPICP) followed the same protocol as used in the PCP technique, except between the first passive stretch and the concentric contraction of the hip flexors, a 3-s maximum voluntary isometric contraction (MVIC) of the hip extensors was performed. A 2-s gradual contraction was initiated by easing into a MVIC to help maintain as close as an isometric contraction as possible. The subject was asked to relax at the completion of the MVIC while the investigator maintained the stretch of the hip extensors. Technique 4 (SPICP) also followed the same procedures as Technique 3, except a 3-s MVIC of the hip flexors rather than for the hip extensors was performed.

Instrumentation

Flexibility. A Leighton flexometer was used to measure hip flexion in degrees of motion for the dominant leg. The instrument has been shown to provide reliable (> .97) measures of hip flexion (Leighton, 1942). The Flexometer contains a weighted 360° dial and pointer. Independent locking devices are provided for the pointer and dial at any given position throughout the ROM.

Skinfolds. A Lange caliper was used to assess skinfolds in which three trials were taken with an average serving as the data point for each site. The instrument provided a constant force of 10/mm at the skinfold site (Lohman & Pollock, 1981).

Analysis

Each individual performed three stretching trials, all separated by a 2-min rest, and thus three values for ROM were determined for each subject. The average of the measures from the three trials was used as the criterion measure of ROM for each subject in the statistical analyses. Data were analyzed using a 2 (cold/no cold condition) x 4 (stretching techniques) ANOVA. A Tukey multiple comparison test was used as appropriate. A preset alpha level of .05 was selected.
Results and Discussion

Physical characteristics of the subjects are presented in Table 1. Table 2 provides group means for ROM achieved following the various treatments. A strong effect was found for stretching technique (F[3, 112] = 8.677, p < .001). Tukey post hoc tests revealed that results of the P treatment differed from those of the three PNF stretching techniques. Greater flexibility was achieved using the three PNF techniques than using the P technique. There was no effect of the cold application on the ROM achieved following the stretching, F(1, 112) = 0.259, p > .62. There was no interaction effect between cold/no cold and stretching technique, F(9, 112) = 1.004, p > .39.

Adequate range of motion (ROM) or flexibility is an important element of physical fitness and health (Corbin & Noble, 1980). Consequently, flexibility improvement and maintenance are an essential part of any conditioning or rehabilitation program. Numerous techniques have been purported to improve flexibility and to assist in overcoming postural problems and other joint disorders. All three modified PNF stretching techniques, PCP, 3-PLCP, and 5-PLCP, resulted in greater flexibility at the hip joint than did P. This finding is in agreement with results of other studies that found modified PNF maneuvers to be superior to conventional stretching techniques (Cornelius & Hinson, 1980; Etnyre & Abraham, 1986a; Hardy, 1985; Prentice, 1983; Sady, Wortman, & Blanke, 1982; Wallin, Ekblom, Granh, & Nordenborg, 1985). Few investigations, however, have utilized therapeutic modalities, such as cold application, and 3-s maximum voluntary isometric contraction (MVIC) time intervals in conjunction with modified PNF techniques.

There are two possible mechanisms for increasing ROM using modified PNF techniques: (a) autogenic inhibition, which acts to provide muscle relaxation subsequent to an MVC while on stretch (Tangigawa, 1972), and (b) reciprocal inhibition. Autogenic inhibition occurs in response to stimulation of the Golgi tendon organs. These proprioceptors are sensors of tension produced by extramuscular fibers (Guyton, 1991, p. 596). Reciprocal inhibition causes relaxation of the target muscles (antagonists) concomitant with concentric contraction of the opposite muscle group (Guyton, 1991, p. 598). Etnyre and Abraham (1986b) suggested that PNF methods involving reciprocal inhibition are associated with the greatest potential for muscle compliance through inhibitory neural influences.

The PCP technique would be expected to elicit reciprocal inhibition in the target muscles consequent to the concentric contraction of the agonists (hip flexors). The PLCP technique theoretically elicits reciprocal inhibition in the target muscles consequent to both the isometric contraction of the flexors and the concentric contraction of the flexors. The PLCP technique also theoretically elicits reciprocal inhibition and should elicit autogenic inhibition consequent to the isometric contraction of the target muscles. All three techniques include concentric contraction of the agonists; therefore, differences in ROM among the three techniques would be attributed to the effects of additional reciprocal inhibition (PLCP) or to the effects of autogenic inhibition (PLCP). All techniques in this study were equally effective. Thus, the results of this study did not reveal additional benefits to ROM with the use of prestretch contraction of the target muscle or with prestretch contraction of the agonist muscle. Furthermore, because all three PNF techniques were superior to the passive technique (in which reciprocal inhibition is not elicited), the results provide some evidence in support of reciprocal inhibition as being the strongest influence in PNF stretching methods.

The finding in the present study, that there appears to be no increase in ROM with the addition of cold application prior to stretching, is in agreement with the results of Rosenberg et al. (1990). They compared the effectiveness of PCP and 3-PLCP stretching techniques, with and without cold application, on hip ROM in healthy, elderly female subjects and reported no effect of the cold application. In that study, cold was applied using a Col Pac Hydrocollator Master Chilling Unit. In contrast, Cornelius and Jackson (1984) reported that cold application through the Col Pac Hydrocollator unit enhanced the effectiveness of PCP and 3-PLCP techniques in increasing hip ROM in male college students.

Previous studies involving cold treatments and stretching techniques have not controlled for body composition. Rosenberg et al. (1990) suggested that excess body fat could reduce the effectiveness of the cold application by impeding cold conductance to the target muscle. For this reason a criterion for participation in the present...
study was that subjects have 18% or less body fat. Electrical activity in the muscle is reduced following cryotherapy; cold increases the threshold stimulus to which the muscle spindle will respond (Lippold, Nicholls, & Redfearn, 1960). Thus, cold application would be expected to attenuate the stretch reflex, which should result in a more relaxed muscle and greater ROM.

Prentice (1982) reported effective muscle relaxation and reduction in pain with the use of cold application followed by both static stretching and a slow reversal hold relax (SRHR) PNF flexibility technique but did not compare responses to the techniques performed with and without cold application. The results of the present study suggest that there is no measurable benefit of cold application prior to performance of stretching exercises on ROM.

The three modified PNF stretching techniques all share contraction of the agonist muscles. Our results provide evidence that the resultant reciprocal inhibition of target muscles may be responsible for the enhanced ROM because addition of the 3-s MVIC of the flexors or extensors, designed to elicit either additional reciprocal inhibition or autogenic inhibition, respectively, had no apparent effect on measured ROM. Furthermore, despite the potential effect of cold application in reducing muscle spindle activity, results of this study suggest that the effectiveness of the modified PNF techniques may not be enhanced by application of cold.

References


Authors' Note

Please address correspondence to William L. Cornelius, Department of Kinesiology, Health Promotion, and Recreation, Exercise Physiology Laboratory, University of North Texas, P.O. Box 15857, Denton, TX 76203-3857.