Hot and Cold Whirlpool Treatments and Knee Joint Laxity

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Abstract:

Objective: To examine the influence of clinical applications of heat and cold on arthrometric laxity measurements of the knee.

Design and Setting: The knee joint was submersed 4 inches above the patella in hot and cold whirlpools containing water of 40°C and 15°C for 20 minutes. A control was also performed to provide a neutral temperature comparison group.

Subjects: Eight males and 7 females with no history of knee injury.

Measurements: The knee was maintained at 20° flexion and tibial rotation at either 15° of internal rotation, 15° of external rotation, or a neutral measurement with a modified KT-1000 knee arthrometer equipped with an LCCB-50 strain gauge that allowed for the digital display of the applied distraction forces. Order of testing was counterbalanced. Subjects underwent each condition once, with each trial on separate days. Two 2-factor repeated measure analyses of variance were performed to test effects of temperature on knee laxity for the dependent measure (laxity at 89N and at maximal displacement forces).

Results: There was no thermal effect on displacement at 89N nor at maximal distraction ($p > .05$). A difference was found with respect to test position, with external rotation showing a greater displacement than internal rotation ($p < .05$).

Conclusions: There was no evidence that hot or cold whirlpool treatments alter knee laxity as assessed with the KT-1000. Rotation of the tibia does affect the magnitude of displacement of the knee. Further research is needed to determine if these findings can be applied to ACL-deficient or ACL-reconstructed knees.

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The anatomy and function of the knee has been classified into muscular, or dynamic, components, and ligamentous, or static, components.[6],[10] The quadriceps, hamstrings, popliteus, gracilis, sartorius, iliotibial band, and gastrocnemius all cross the knee and, with the inclusion of the synovial capsule of the knee, can be viewed as secondary restraints.[8,10,15] The hamstring [6,10,18,24] and popliteus [10,16] have been most definitively viewed as secondary muscular restraints to anterior translation of the tibia on the femur. The ligamentous or static component has been viewed as the primary stabilizer of the knee. The role and function of the medial and lateral collateral ligaments and the anterior and posterior cruciate ligaments are well documented.[1,3,4,7,12,13,15,16,19,20] The anterior cruciate is perhaps the subject of the most research and viewed as the most important ligament in terms of maintaining knee stability and function.[5]

The role of knee arthrometry in quantifying knee laxity has been extensively covered in the literature.[2,9,11,17,22,28,29] The KT-1000 knee arthrometer (MEDmetric Corporation, San Diego, CA) is one of the most accurate and reliable methods of quantifying knee joint laxity when compared to other arthrometers.[2,9,17,22,26,28,29]

Although the effects of exercise on knee joint laxity have been reported,[14,25,27,30] the effect of clinical modalities on knee joint laxity has not been studied. Thermal effects which may influence tissue elasticity, muscle tonus, muscle spindle activity, and patient pain threshold[23] have not been investigated in research pertaining to the knee. The purpose of this study was to examine the effects of a hot and cold whirlpool treatment on knee joint laxity assessed with the tibia in the neutral, internally rotated, and externally rotated positions, with 89N and maximal displacement forces applied by a KT-1000.

METHODS

Fifteen subjects volunteered for this study (8 males and 7 females; age = 22.8 ± 2.5 yr; ht = 67.5 ± 5.5 in; wt = 166.7 ± 49.4 lb). Criteria for selection was that all subjects reported no history of knee injury. Before enrollment in the study, each subject read and signed a consent form approved by the University of Virginia's Institutional Review Board.

A modified KT-1000 knee arthrometer was used to measure anterior laxity in all subjects. The arthrometer was equipped with an LCCB-50 strain gauge (Omega Technologies, Inc, Stamford, CT) that allowed for digital display of the applied distraction forces. The Tibial Fixator Device[21] was used to maintain knee angle at 20° flexion and to control tibial rotation during the laxity measurements. Applications of heat and cold were administered by submersion of the knee joint 4 inches above the patella in whirlpools containing water of 40°C and 15°C, respectively.

Procedure

Subjects, wearing shorts, were asked to sit on an examining table with knees extended and supported for 20 minutes. This was done to allow for a common beginning joint temperature of all subjects and to reduce the effects of any pretesting activity by the subjects. Subjects were then required to spend 20 minutes with their knee in a hot or cold whirlpool, or in a control position with the knee at 90° flexion and the leg hanging off the table in the air. The control was performed to provide a neutral temperature comparison group for the hot and cold trials. The hanging of the limb off of the table was done to provide gravity effects similar to those present during the whirlpool protocols. Each subject underwent each condition once, with each trial occurring on a separate day. The order of trial conditions was counterbalanced.

Anterior Tibial Displacement (mm) During Normal, Cold, and Hot Conditions (Mean±SD)

	External Rotation				Neutral				Internal Rotation			
	89N		Maximal		89N		Maximal		89N		Maximal	
No whirlpool	4.1	± 2.0	6.8	± 2.8	3.5	± 2.1	6.1	± 2.7	3.1	± 2.1	5.7	± 2.9
15°C whirlpool	4.2	± 2.1	6.7	± 3.0	3.8	± 2.0	6.9	± 3.4	3.3	± 1.4	6.0	± 2.2
40°C whirlpool	3.8	± 1.9	6.3	± 2.9	3.4	± 1.7	5.9	± 2.7	2.7	± 1.5	5.4	± 2.2

Following each whirlpool condition, the subject was placed in the Tibial Fixator Device at 20° knee flexion in either 15° of internal rotation, 15° of external rotation, or a neutral position. The order of testing positions was counterbalanced. The KT-1000 was then positioned on the subject according to standard protocol.[9] The tibia was anteriorly displaced with a recorder marking the newtons of force being applied to elicit 1 mm increments of displacement, until no further displacement could be achieved. The subject was then repositioned and retested at each of the remaining two positions of tibial rotation. All testing was performed by the same individual throughout the study.

Data Analysis

Statistical analysis was performed on the data using the Statview 512+ (Abacus Concepts, Inc, Calabasas, CA) statistical package. Two two-factor (thermal condition and rotation) repeated measure analyses of variance were performed to test effects of temperature on knee laxity for the dependent measures. Laxity at 89N and at maximal displacement forces were the dependent measures.

RESULTS

There was no thermal effect on displacement at 89N of distraction nor at maximal distraction ($p > .05$; see the Table). A difference was found with respect to test position, with external rotation showing a greater displacement than internal rotation ($p < .05$).

DISCUSSION

Since hot and cold whirlpool treatments had no effect on anterior displacement of the tibia as assessed with instrumented knee arthrometry, we feel that athletes with uninjured knees undergoing pre-exercise thermal treatment are not predisposed to increased anterior knee laxity.

Our observation that a significant difference in anterior laxity occurred when the knee was in 15° of external rotation as compared with the knee at 15° internal rotation is in agreement with other researchers.[11,21] The degree of tibial rotation is important in determining intratester and intertester reliability with the KT-1000.[11,25]

Clinicians using the KT-1000 for repeated assessments of patients should consider tibial position as an important factor in obtaining more consistent results.

Future research is needed to determine whether the findings of this study can be applied to ACL-deficient or ACL reconstructed knees. The presence of greater anterior knee laxity may show differing results when subjected to similar thermal conditions, because injured or reconstructed knees may have a greater muscular stability component than do uninjured knees.

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