

## ORIGINAL RESEARCH

## THE EFFECTIVENESS OF DRY NEEDLING AND STRETCHING VS. STRETCHING ALONE ON HAMSTRING FLEXIBILITY IN PATIENTS WITH KNEE PAIN: A RANDOMIZED CONTROLLED TRIAL

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## ABSTRACT

**Background:** Recently, dry needling has emerged as a popular treatment for muscular pain and impairments. While there are numerous studies detailing the benefits of dry needling for pain, few studies exist examining the effects on soft tissue mobility.

**Purpose:** The purpose of this study was to determine if the addition of hamstring dry needling to a standard stretching program results in greater improvements in hamstring flexibility compared to sham dry needling and stretching in subjects with atraumatic knee pain. Additionally, squat range of motion, knee pain, and the Lower Extremity Functional Scale were compared between the two groups.

**Study Design:** Double blinded randomized controlled trial.

**Methods:** Thirty-nine subjects were randomized to receive either dry needling (n = 20) or sham (n = 19) dry needling in addition to hamstring stretching, to all detected hamstring trigger points on two visits. All dependent variables were measured at baseline, immediately post intervention, and 1, 3, and 7 days after the initial treatment. Each subject also performed hamstring stretching three times daily for one week.

**Results:** Significant improvements in hamstring range of motion and all other dependent variables were observed across time regardless of treatment group. However, the lack of significant time by group interactions indicated the improvements were not different between dry needling and sham dry needling groups.

**Conclusions:** The results of the current randomized controlled trial suggest that two sessions of dry needling did not improve hamstring range of motion or other knee pain-related impairments more than sham dry needling in a young active population with atraumatic knee pain.

**Level of Evidence:** Therapy, Level 2

**Keywords:** Flexibility, lower extremity, trigger point

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## INTRODUCTION

Flexibility and mobility have long been an integral part of many rehabilitation and fitness training programs for patients with non-traumatic knee pain. Muscle tightness, as it contributes to hip and knee range of motion, can limit the execution of large joint, multi-segmental movements such as squatting, lunging, and deadlifting. A decreased ability to perform these movements could potentially lead to decreased physical performance as well as increased risk of injury.<sup>1-3</sup> Kibler<sup>4</sup> suggests that where there is a deficiency in a proximal segment of the kinetic chain, changed workloads may be required in the more distal segments in order to preserve the same movement outcome at the most distal segment. If this is the case, patients presenting with overuse or overload injuries of the limbs may also experience dysfunction in more proximal segments.

When compared to healthy controls, patients with non-traumatic knee pain have demonstrated significantly less flexibility of lower extremity soft tissues, including the hamstrings.<sup>5,6,7</sup> Hamstring mobility, as it contributes to hip and knee range of motion, is important for the proper execution of functional movement patterns such as squatting, deadlifting, lunging, etc commonly required in athletic and training environments.

Hamstring stretching has been used for many years as a common intervention among physical therapists, athletic trainers, and fitness/coaching professionals to improve mobility at the hip and knee as well as to decrease muscle soreness.<sup>8</sup> Numerous studies have examined the duration of a single stretch as well as the period of time required to effect significant improvement in hamstring flexibility utilizing a variety of muscle stretching techniques such as active, passive, and assisted stretching. Little consensus exists in the literature about the optimal period of time needed to show improvements with some studies suggesting as little as 4 weeks and other studies suggesting as many as 12 weeks to effect optimal change.<sup>9-11</sup> The immediate effects of an acute bout of stretching on knee range of motion have been observed to only last 3-6 minutes.<sup>12,13</sup>

One potential cause of restricted range of motion related to local muscle dysfunction is the myofascial trigger point (TP).<sup>14</sup> TPs are described as localized hyperirritable areas associated with hypersensitive palpable taut bands located in muscle tissue, and are

suggested to contribute to joint range of motion restrictions as well as adversely affect muscle activation.<sup>15-19</sup> TPs are further described in the literature as being either active or latent.<sup>20</sup> Active TPs can be responsible for local pain as well as referred pain or paresthesia<sup>21</sup> and may contribute to spontaneous pain at rest.<sup>20</sup> Latent TPs are focal areas of tenderness and tightness in muscle tissue. Unless stimulated by direct contact, muscle activation, or stretching, latent TPs are not responsible for local or referred pain. These TPs may lead to altered muscle activation patterns resulting in limited range of motion or weakness of the muscles involved.<sup>14,20,21</sup> TPs may also develop secondary to an excessive release of acetylcholine from motor endplates which has been associated with increased motor endplate noise and resulting muscle fiber knots.<sup>16</sup>

Dry needling (DN) has emerged as a popular intervention to address muscular pain and dysfunction. While multiple theories exist regarding the physiological mechanisms elicited by DN, the functional effects remain largely anecdotal.<sup>22-25</sup> These effects appear to be most pronounced when a local twitch response is elicited.<sup>23</sup> A local twitch response is an involuntary spinal cord reflex contraction of muscle fibers following needling of the involved fibers.<sup>26,27</sup> While numerous studies exist detailing the benefits of dry needling for pain,<sup>18,24,28,29</sup> few studies exist examining the effects on soft tissue flexibility.<sup>10,13,27</sup>

The primary purpose of this study was to determine if the addition of DN to a standard stretching program results in greater improvements in hamstring flexibility versus stretching alone in patients with atraumatic knee pain over the course of one week. The secondary purpose was to compare changes in knee flexion range of motion while squatting; patient reported changes in knee pain with provocative movements, and self-reported disability. It was hypothesized that subjects who received DN and stretching would have greater improvements in hamstring flexibility, pain, and knee range of motion during a squat compared to subjects who only performed stretching.

## METHODS

### Participants

Subjects presenting with a chief complaint of atraumatic knee pain were recruited from a direct access physical therapy clinic. Using G Power 3.1.2<sup>30</sup> we deter-

mined a sample size of 36 prior to commencement of the trial. This sample size provided 80% power to detect a change of 10° in range of motion on the active straight leg raise (ASLR) and active knee extension (AKE) with an alpha level of 0.05. Previous authors who have studied hamstring injuries and cervicgia demonstrated 10-12° changes after one week of treatment in subjects that responded favorably to a DN intervention.<sup>15,29</sup> The study protocol was approved by the institutional review board of Keller Army Community Hospital (West Point, NY) and registered with ClinicalTrials.gov (ClinicalTrials.gov Identifier: NCT02498704). All participants signed an informed consent form prior to inclusion in the study. Participants' rights were protected through the duration of the study.

To be included in the study subjects had to present with a chief complaint of atraumatic knee pain with duration of symptoms greater than two weeks. Subjects also had to demonstrate a deficit of at least 20° of knee extension on the AKE test. Hamstring tightness was operationally defined as a greater than 20° loss of knee extension during the AKE test as measured with the subject supine and the femur held at 90° of hip flexion.<sup>9</sup> Additional study inclusion and exclusion criteria are presented in Table 1. A screening physical examination of each knee was performed consisting of a Lachman's test, Posterior Drawer Test, Valgus and Varus stress a 0° and 30°, Bounce Home Test, McMurray's Test, and Thessaly Test in order to rule out ligamentous deficiency and/or meniscus tears. Subject flow diagram is presented in Figure 1.

## INTERVENTIONS

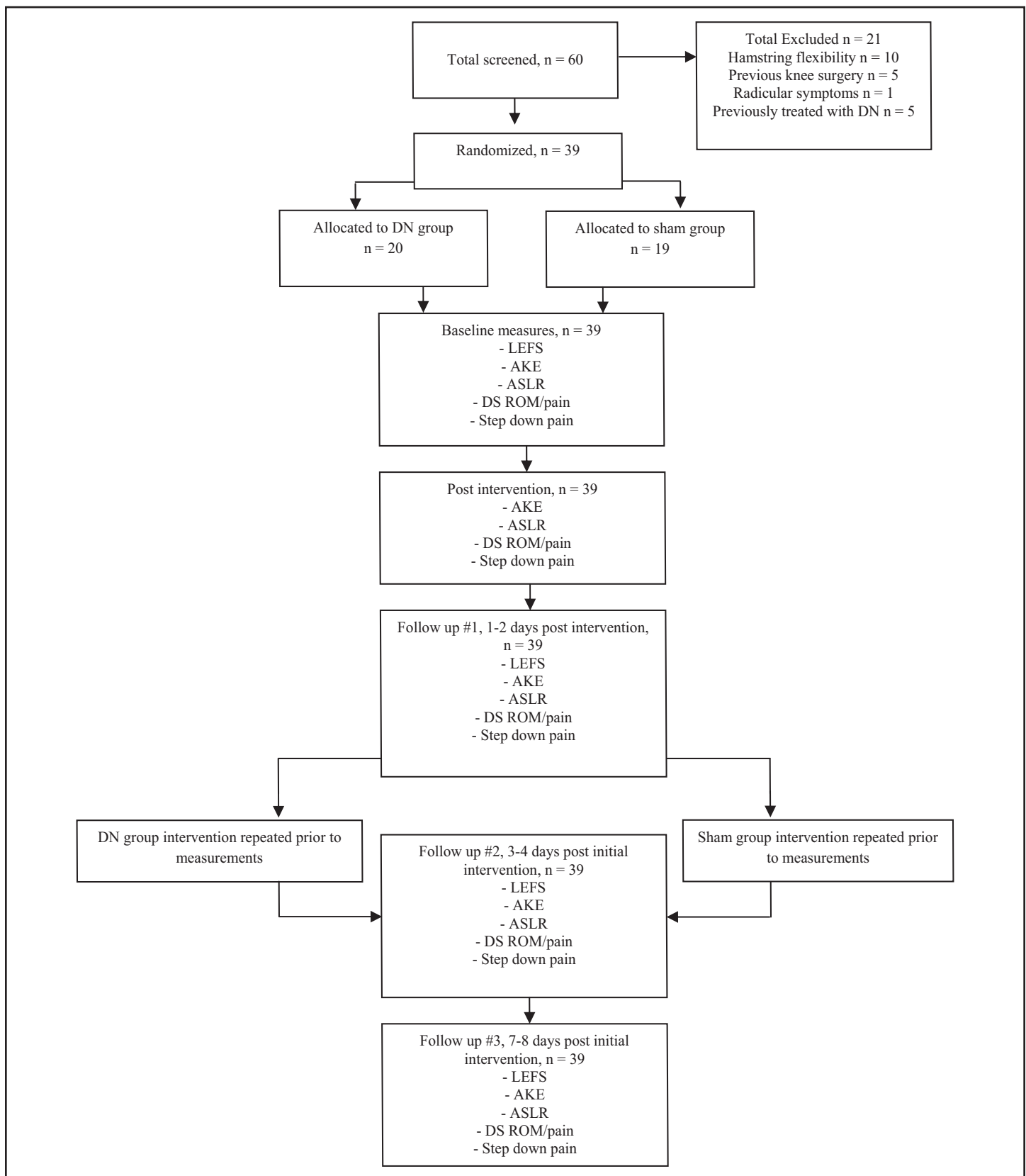
The randomization schedule was computer-generated, with assignments placed in opaque, sequen-

tially numbered envelopes by an investigator not involved with recruitment or data collection. Treatment allocation was revealed to the investigator performing the intervention after collection of baseline measurements. Subjects and investigators taking all measurements were blinded to the intervention. Subjects were randomly assigned to one of two groups: a DN group and a sham DN group. After completion of all initial measurements, each subject received the assigned treatment. Manual palpation of the bilateral biceps femoris, semitendinosus, and semimembranosus was performed to detect the presence of TPs in the DN group. A provider with greater than three years of DN experience performed dry needling to all detected TPs with the subject in the prone position to allow access to the posterior thigh as well as to maintain blinding of the subject. Subjects included in this study complained of anterior knee, not hamstring-region, pain; all TPs identified were latent TPs. Upon identification of a TP a solid monofilament needle (Seirin Corp., Shizuoka, Japan) was inserted into the skin directed towards the target TP (Figure 2). The needle was then repeatedly "pistoned" (inserted and withdrawn rapidly from each TP) without being fully withdrawn from the skin with the goal of eliciting a local twitch response.<sup>23,31</sup> Treatment was repeated to produce several local twitch responses and continued until all identified areas of dysfunction had been addressed.

Sham DN was implemented using a standard plastic tube as utilized in regular DN, however, instead of a monofilament needle each tube contained a small disinfected finishing nail. Subjects in the sham DN group were positioned identically to subjects in the DN group. Sham DN was performed at three points over

**Table 1.** *Inclusion and exclusion criteria*

Males and females	History of herniated lumbar disc/radiculopathy
Age 18-40 DoD beneficiaries	Prior surgery in the hip, knee, or back
Lack of ≥20 degrees of supine active knee extension	Self-reported pregnancy
Atraumatic knee pain ≥2 weeks	History of blood borne pathogens/infections disease/active infection
	Metal allergy
	Positive instability tests indicative of ligamentous tear
	Joint line tenderness or positive meniscal tests
	Participants not fluent in English
	Previous history of DN
	Bleeding disorders or current use of anticoagulant medications



**Figure 1.** Subject recruitment/retention flow diagram. DN, dry needling; LEFS, lower extremity functional scale; AKE, active knee extension; DS, deep squat; ASLR, active straight leg raise; ROM, range of motion





**Figure 2.** *Hamstring dry needling. Insertion of monofilament needle into lateral hamstring muscle belly towards suspected trigger point.*

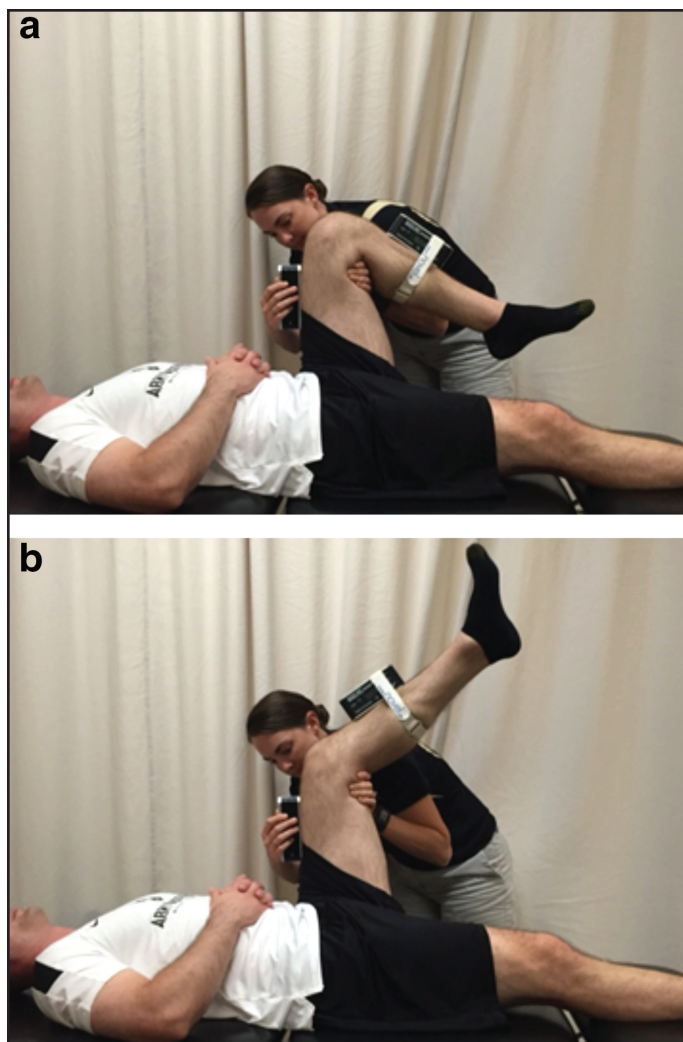
the lateral hamstrings and three points over the medial hamstrings without the intention of locating any TPs. Similar technique to the DN was used to include a pistoning motion but the skin was not punctured at any time in this group. The same investigator measured each subject at every time point. The assigned treatment was repeated one additional time in the identical manner as detailed above three days later.

Post-intervention, all subjects were given a standing hamstring stretch to perform one repetition held for 30 seconds, repeated three times daily.<sup>32</sup> These parameters have been shown to be effective at improving hamstring flexibility. The stretch was performed with the involved leg elevated on a chair or stool. While standing tall, maintaining neutral spine posture, and keeping the involved knee in full extension, subjects were instructed to lean forward hinging at the hips until moderate stretch discomfort in the hamstrings was felt. Subjects were instructed by demonstration and were provided with a handout of stretching instructions to perform at home. Subjects were also provided with an exercise log to record home exercise compliance.

## OUTCOMES

The primary outcome measure was hamstring flexibility (as measured by the AKE and ASLR). Two

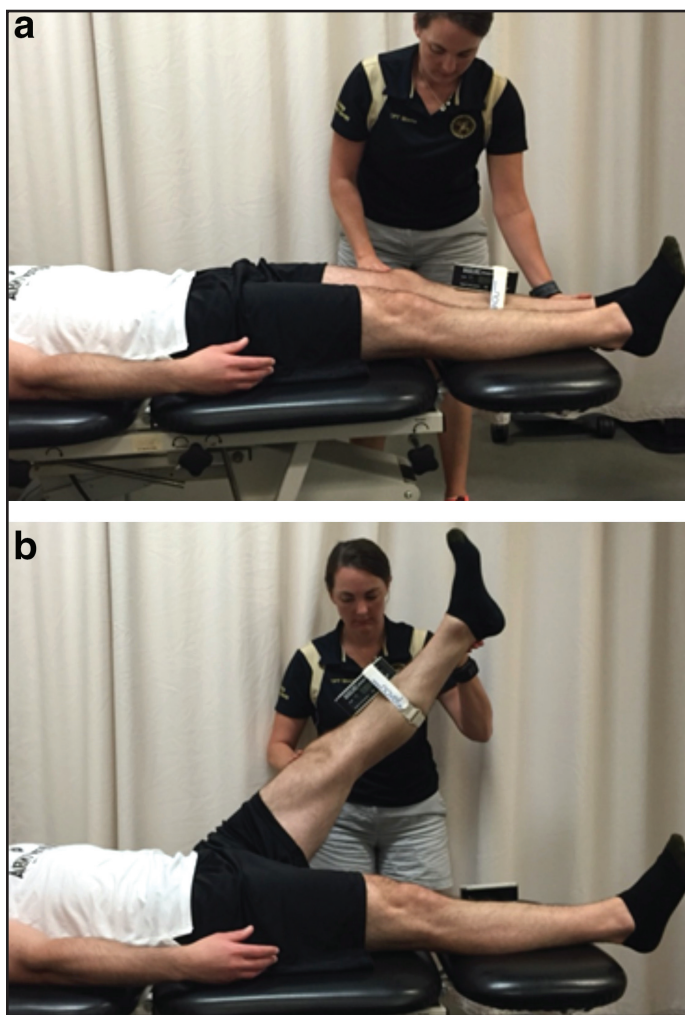
investigators (one to maintain proper test position, the second to record the measurement) were utilized for the AKE. (Figure 3) The involved extremity was held in 90° hip and knee flexion with the contralateral posterior knee in contact with the table. Saunders digital inclinometers (Chaska, Minnesota) were used for measurements. Straps were placed on the distal leg at mid-calf to secure an inclinometer in line with the tibial tuberosity. A second inclinometer was held in place at mid-thigh in order to assure that the subject maintained 90° of hip flexion. The subject was directed to actively extend the knee as far as tolerated without loss of the test position. The distal inclinometer was used to measure knee angle. The test was performed twice and the average of the



**Figure 3.** (a.) Active knee extension test. Vertical position of the thigh is maintained with one goniometer. (b.) Active knee extension test. Active knee extension angle is measured with a second goniometer.

two trials was recorded. The AKE test is a valid and reliable measure of hamstring flexibility.<sup>33–35</sup>

The ASLR was also performed with the subject supine. (Figure 4) The subject was instructed to actively raise the leg by flexing at the hip while maintaining full knee extension and ankle dorsiflexion. The contralateral limb had to remain in contact with the table to prevent contralateral hip flexion. A digital inclinometer was placed on the anterior lower leg in-line with the tibial tubercle. The test was performed twice and the average of the two trials was recorded. There is strong correlation between the AKE and ASLR tests.<sup>33</sup> While the ASLR is not a true measure of hamstring flexibility, this test may demonstrate changes in hip and/or nerve mobility influenced by improvements in hamstring flexibility.<sup>33</sup>



**Figure 4.** (a.) Active straight leg raise. Subject actively raises leg while maintaining full knee extension and keeping contralateral posterior knee in contact with the table. (b.) Active straight leg raise. Hip flexion angle measured with goniometer on tibia.

Secondary outcome measures included pain reported during basic functional tasks and self-reported function on the Lower Extremity Functional Scale (LEFS). Following hamstring measurements, subjects performed a deep squat. Subjects started with feet shoulder width apart, shoulders flexed to 90°, and elbows fully extended. While maintaining heels in contact with the ground, subjects were instructed to squat as deeply as possible or until an increase in knee pain was experienced. Knee flexion was measured at that point with a standard goniometer. Subjects recorded knee pain during the squat on the Visual Analog Scale (VAS). The VAS is a valid and reliable tool for measuring acute and chronic pain.<sup>36–38</sup>

Next, subjects performed a single leg step down from a 15 centimeter step. Standing on the involved leg, subjects performed a controlled eccentric step down in their normal manner to the uninvolved leg. Subjects recorded knee pain during the step down on the VAS. An investigator blinded to group assignment performed all measurements.

Self-reported knee pain and function were assessed in all subjects at initial enrollment with the LEFS. The LEFS is a self-report questionnaire assessing initial function, ongoing progress, and outcomes concerning 20 different tasks ranging from activities of daily living to hobbies and exercise. The LEFS is a reliable and valid tool for assessing outcomes in lower extremity injuries with a minimal clinically important difference of nine points.<sup>39,40</sup>

Repeat measurements of all variables were obtained at four time points: immediately post intervention, and one day, three days, and seven days following the initial intervention. Prior to measurements on the third visit, an additional session of DN/sham intervention was performed in the identical manner described above. At the final visit, each subject was asked to predict his or her group assignment. All measurements performed pre-intervention were repeated post-intervention in both groups by the same investigator who remained blinded to group assignment.

## DATA ANALYSIS

Data analysis was performed with statistical analysis software R version 3.0.2 and SPSS version 18 (Chicago, IL). Means, standard deviations, and 95% confidence intervals (CIs) were calculated for each variable.



A 2x5 mixed model analysis of variance (ANOVA) with Sidak's post hoc testing was used for each outcome measures with time (pre and post intervention, follow up 1, 2, and 3) as the within-subject factor and group (DN or sham DN) as the between-subject factor. Intraclass correlation coefficients (ICCs), model [3,2] were calculated to ensure intra-rater reliability for AKE and ASLR measurements.

## RESULTS

Sixty consecutive patients with atraumatic knee pain were screened for eligibility criteria between January and September 2015. Thirty-nine patients (37 males, 2 females) met the inclusion criteria and agreed to participate. Subjects were randomly assigned to the DN group (n = 20) or a sham DN group (n = 19). Baseline statistics for the DN and sham DN group are found in Table 2. No subjects were lost to follow up after initial enrollment and no adverse events were reported. All participants were analyzed in the groups to which they were assigned. Upon visual inspection of the data there appeared to be a difference in baseline pain with step down between the sham (mean VAS 10.5) and DN (mean VAS 22.84) groups. Because of this potential difference analysis of covariance (ANCOVA) was utilized to assess differ-

ences in pain with step down. Otherwise, no statistically significant differences were observed between groups at baseline. Substantial intra-rater reliability for AKE and ASLR was demonstrated for both investigators. ICCs for investigator 1 and 2 were between 0.89 and 0.99 for AKE and ASLR respectively.

The 2-by-5 ANOVA failed to show a significant time by group interaction for AKE ( $F = 0.83$ ,  $p = 0.51$ ), ASLR ( $F = 0.29$ ,  $p = 0.89$ ), deep squat ROM ( $F = 0.69$ ,  $p = 0.60$ ), pain with deep squat ( $F = 0.58$ ,  $p = 0.67$ ) and self-reported function ( $F = 1.73$ ,  $p = 0.17$ ). The results of the 2-by-5 ANCOVA for pain during a step down also failed to demonstrate a significant difference between groups ( $F = 2.30$ ,  $p = 0.47$ ).

A statistically significant main effect for time was observed overall suggesting improvements in AKE ( $F = 3.94$ ,  $p < 0.01$ ), ASLR ( $F = 4.04$ ,  $p < 0.01$ ), deep squat ROM ( $F = 10.34$ ,  $p < 0.001$ ), pain with deep squat ( $F = 11.44$ ,  $p < 0.001$ ), pain during a step down ( $F = 8.78$ ,  $p < 0.001$ ), and self-reported function ( $F = 12.79$ ,  $p < 0.001$ ) across all participants. Post hoc comparisons with Sidak corrections also demonstrated statistically significant improvements from baseline to final follow up for both groups in all variables. Statistically significant improvements in pain and ROM with deep squat were demonstrated for both groups at all time points compared to baseline. Outcome data for primary and secondary outcome measures are presented in Table 3.

## DISCUSSION

The outcomes of the current randomized controlled trial suggest that two sessions of hamstring DN with daily stretching for one week did not result in larger improvements in ROM, pain, and self-reported function compared to daily stretching and sham needling in patients with atraumatic knee pain. Participants in both groups demonstrated statistically significant improvements across all measures at the final follow up when compared to baseline. These observations may be a result of hamstring stretching, sham DN, or simply the passage of time, however, which of these influenced the results cannot be known, because a group that received no intervention was not included in this study.

These results are consistent with previous observations of Huguenin et al,<sup>41</sup> who reported no sig-

**Table 2.** Baseline and descriptive statistics by group

	Baseline Mean ( $\pm$ SD) DN Group	Baseline Mean ( $\pm$ SD) Sham Group
Age (years)	20.3 (1.08)	20.16 (2.12)
Gender	20 male	17 male 2 female
Duration of symptoms (weeks)	17.75 (26.10)	14.3 (16.36)
AKE (degrees)*	47.72 (9.70)	49.59 (17.10)
ASLR (degrees)*	52.26 (10.84)	55.33 (13.35)
Deep Squat ROM (degrees)*	110.35 (24.73)	108.50 (24.18)
Deep Squat pain (VAS)*	22.40 (22.79)	24.11 (24.75)
Step Down pain (VAS)*	10.50 (14.27)	22.84 (22.34)
LEFS Score	65.35 (10.47)	64.47 (10.78)
DN = dry needling SD = standard deviation ROM = range of motion *Measurements taken on the symptomatic limb		
AKE = active knee extension ASLR = active straight leg raise LEFS = lower extremity functional scale		

**Table 3.** Outcome data for LEFS, ROM, and pain by group

Variable	Baseline mean (± SD)	Post treatment mean (± SD)	FU 1 mean (± SD)	FU 2 mean (± SD)	FU 3 mean (± SD)
DN group AKE	47.72 (9.70)	48.68 (13.34)	50.34 (11.48)	49.31 (9.38)	55.51 (12.66)
Sham group AKE	49.59 (17.10)	52.98 (9.64)	52.64 (9.25)	54.73 (7.41)	55.20 (7.68)
Within-group change score from baseline					
DN	--	0.96 (-6.51, 8.43) <sup>‡</sup>	2.62 (-4.18, 9.42) <sup>‡</sup>	1.59 (-4.52, 7.70) <sup>‡</sup>	7.79 (0.57, 15.01) <sup>‡</sup>
Sham	--	3.39 (-5.74, 12.52) <sup>‡</sup>	3.05 (-6.00, 12.10) <sup>‡</sup>	5.14 (-3.53, 13.81) <sup>‡</sup>	5.61 (-3.11, 14.33) <sup>‡</sup>
Between-group difference in change score	--	-2.43 (-10.02, 5.16) <sup>‡</sup>	-0.43 (-7.22, 6.36) <sup>‡</sup>	-3.55 (-9.05, 1.95) <sup>‡</sup>	2.18 (-4.66, 9.02) <sup>‡</sup>
DN group ASLR	52.26 (10.84)	55.28 (12.43)	55.60 (7.50)	57.00 (8.08)	59.47 (9.41)
Sham group ASLR	55.33 (13.35)	56.82 (8.38)	57.71 (7.87)	59.00 (6.82)	59.43 (6.88)
Within-group change score from baseline					
DN	--	3.02 (-4.45, 10.49) <sup>‡</sup>	3.34 (-2.63, 9.31) <sup>‡</sup>	4.74 (-1.38, 10.86) <sup>‡</sup>	7.21 (0.71, 13.71) <sup>‡</sup>
Sham	--	1.49 (-5.84, 8.82) <sup>‡</sup>	2.38 (-4.83, 9.59) <sup>‡</sup>	3.67 (-3.31, 10.65) <sup>‡</sup>	4.10 (-2.89, 11.09) <sup>‡</sup>
Between-group difference in change score	--	1.53 (-3.43, 6.49) <sup>‡</sup>	0.96 (-4.03, 5.95) <sup>‡</sup>	1.07 (-3.79, 5.93) <sup>‡</sup>	3.11 (-2.26, 8.48) <sup>‡</sup>
DN group deep squat ROM	110.35 (24.73)	114.73 (24.44)	120.85 (23.86)	121.78 (23.87)	123.30 (23.54)
Sham group deep squat ROM	108.50 (24.18)	115.21 (23.74)	114.90 (21.85)	122.03 (17.08)	119.92 (20.64)
Within-group change score from baseline					
DN	--	4.38 (-11.35, 20.11) <sup>‡</sup>	10.50(-5.06, 26.06) <sup>‡</sup>	11.43 (-4.13, 26.99) <sup>‡</sup>	12.95 (-2.51, 28.41) <sup>‡</sup>
Sham	--	6.71 (-9.06, 22.48) <sup>‡</sup>	6.40 (-8.76, 21.56) <sup>‡</sup>	13.53 (-0.24, 27.30) <sup>‡</sup>	11.42 (-3.37, 26.21) <sup>‡</sup>
Between-group difference in change score	--	-2.33 (-17.97, 13.31) <sup>‡</sup>	4.10 (-10.77, 18.97) <sup>‡</sup>	-2.10 (-15.63, 11.43) <sup>‡</sup>	1.53 (-12.87, 15.93) <sup>‡</sup>
DN group deep squat pain (VAS)	22.40 (22.79)	15.48 (20.71)	10.50 (15.25)	8.60 (14.82)	8.95 (16.19)
Sham group deep squat pain (VAS)	24.11 (24.75)	19.42 (23.14)	18.21 (20.70)	13.63 (18.89)	14.95 (20.96)
Within-group change score from baseline					
DN	--	-6.92 (-20.86, 7.02) <sup>‡</sup>	-11.90 (-24.31, 0.51) <sup>‡</sup>	-13.80 (-26.11, -1.49) <sup>‡</sup>	-13.45 (-26.10, -0.80) <sup>‡</sup>
Sham	--	-4.69 (-20.45, 11.07) <sup>‡</sup>	-5.90 (-20.76, 8.96) <sup>‡</sup>	-10.48 (-24.97, 4.01) <sup>‡</sup>	-9.16 (-24.25, 5.93) <sup>‡</sup>
Between-group difference in change score	--	-2.23 (-16.46, 12.00) <sup>‡</sup>	-6.00 (-17.75, 5.75) <sup>‡</sup>	-3.32 (-14.30, 7.66) <sup>‡</sup>	-4.29 (-16.40, 7.82) <sup>‡</sup>



**Table 3.** Outcome data for LEFS, ROM, and pain by group (continued)

Variable	Baseline mean (± SD)	Post treatment mean (± SD)	FU 1 mean (± SD)	FU 2 mean (± SD)	FU 3 mean (± SD)
DN group step down pain (VAS)	10.50 (14.27)	6.95 (10.17)	8.05 (10.10)	6.00 (10.40)	6.15 (10.62)
Sham group step down pain (VAS)	22.84 (22.34)	18.32 (20.79)	15.00 (18.19)	10.53 (17.13)	12.95 (18.76)
Within-group change score from baseline					
DN	--	-3.55 (-11.48, 4.38) <sup>‡</sup>	-2.45 (-10.36, 5.46) <sup>‡</sup>	-4.50 (-12.49, 3.49) <sup>‡</sup>	-4.35 (-12.40, 3.70) <sup>‡</sup>
Sham	--	-4.52 (-18.72, 9.68) <sup>‡</sup>	-7.84 (-21.24, 5.56) <sup>‡</sup>	-12.31 (-25.41, 0.79) <sup>‡</sup>	-9.89 (-23.46, 3.68) <sup>‡</sup>
Between-group difference in change score	--	0.97 (-9.56, 11.50) <sup>‡</sup>	5.39 (-4.09, 14.87) <sup>‡</sup>	7.81 (-1.33, 16.95) <sup>‡</sup>	5.54 (-4.29, 15.37) <sup>‡</sup>
DN group step down pain (VAS) <sup>†</sup>	16.51 (14.27)	6.95 (10.17)	8.05 (10.10)	6.00 (10.40)	6.15 (10.62)
Sham group step down pain (VAS) <sup>†</sup>	16.51 (22.34)	18.32 (20.79)	15.00 (18.19)	10.53 (17.13)	12.95 (18.76)
Within-group change score from baseline					
DN <sup>†</sup>	--	-9.56 (-17.49, -1.63) <sup>‡</sup>	-8.46 (-16.37, -0.55) <sup>‡</sup>	-10.51 (-18.50, -2.52) <sup>‡</sup>	-10.36 (-18.41, -2.31) <sup>‡</sup>
Sham <sup>†</sup>	--	1.81 (-12.39, 16.01) <sup>‡</sup>	-1.51 (-14.91, 11.89) <sup>‡</sup>	-5.98 (-19.08, 7.12) <sup>‡</sup>	-3.56 (-17.13, 10.01) <sup>‡</sup>
Between-group <sup>†</sup> difference in change score	--	-11.37 (-21.90, -0.84) <sup>‡</sup>	-6.95 (-16.43, 2.53) <sup>‡</sup>	-4.53 (-13.67, 4.61) <sup>‡</sup>	-6.80 (-16.63, 3.03) <sup>‡</sup>
DN group LEFS	65.35 (10.47)	--	67.75 (8.32)	70.95 (6.14)	72.30 (5.97)
Sham group LEFS	64.47 (10.78)	--	67.11 (9.65)	66.53 (10.65)	69.26 (11.37)
Within-group change score from baseline					
DN	--	--	2.40 (-3.65, 8.45) <sup>‡</sup>	5.60 (0.11, 11.09) <sup>‡</sup>	6.95 (1.49, 12.41) <sup>‡</sup>
Sham	--	--	2.64 (-4.09, 9.37) <sup>‡</sup>	2.06 (-4.99, 9.11) <sup>‡</sup>	4.79 (-2.50, 12.08) <sup>‡</sup>
Between-group difference in change score	--	--	-0.24 (-6.08, 5.60) <sup>‡</sup>	3.54 (-2.06, 9.14) <sup>‡</sup>	2.16 (-3.69, 8.01) <sup>‡</sup>
DN = dry needling SD = standard deviation ROM = range of motion (degrees) <sup>‡</sup> mean (95% confidence interval)					
AKE = active knee extension (degrees) ASLR = active straight leg raise (degrees) FU = follow up; 1, 3, and 7 days after initial intervention <sup>†</sup> calculations based on ANCOVA adjusted mean					
VAS = visual analog scale LEFS = lower extremity functional scale					

nificant changes in straight leg raise or hip internal rotation following gluteal DN or sham DN. The current results indicating no changes in ROM for hamstrings are contrary to previous studies demonstrating significant changes in upper extremity and cervical ROM following DN intervention.<sup>29,42,43</sup>

It is possible that mobility limited by pain rather than muscle dysfunction may demonstrate larger improvements in ROM following DN intervention.

In addition, the hamstrings of the included subjects were not directly injured unlike the subjects of other studies who had muscles treated that were directly involved in an injury. This may explain in part the conflicting results between studies.

It is noteworthy that when asked, 85% (17/20) of subjects in the experimental group, correctly identified true DN, whereas 89.5% (17/19) of subjects in

the sham group incorrectly identified true DN. For future studies utilizing sham needling, these results indicate this methodology could be repeated as subjects unfamiliar with this treatment are not likely to know the difference between sham and true needling. These results also suggest that improvement via placebo effect or patient expectations with treatment cannot be ruled out as previous studies have demonstrated positive results may be based on positive expectations of the subject.<sup>44</sup>

There are a number of limitations in this study. First, DN was only performed twice and to only one muscle group. More demonstrable effects of DN may potentially have been observed with increased frequency and longer duration of treatment and/or treatment of multiple muscle groups involved in hip/knee ROM. While observation of the immediate effect of DN on HS flexibility was desired, a one week follow up period may not have been sufficient to detect overall differences in changes between groups. Second, subjects with atraumatic knee pain of varying origins/sources were included in this study. Hip/core weakness, strength imbalance, and impaired neuromuscular control and timing have also been suggested as contributing factors to apparent hamstring inflexibility and anterior knee pain.<sup>45-48</sup> These additional contributory factors were not assessed in this population. Additional methods of needling to include treatment of corresponding spinal levels as proposed by Gunn<sup>49</sup> were not performed. It is not unreasonable to hypothesize that utilizing various applications of this modality to a more clearly defined diagnostic criterion may yield different results.

Finally, mean duration of symptoms was sixteen weeks (2-104 weeks) and median duration was four weeks. Potential differences may be observed among a population with more chronic symptoms. Finally, detection of the presence of trigger points was not attempted prior to enrollment as part of this study's inclusion criteria as previous studies have failed to establish adequate reliability for detection with physical exam.<sup>50</sup> Consequently, subjects without active trigger points in the HS may have been included. If an insufficient number of trigger points are present within the treated musculature, potential effects of DN may not be as demonstrable.

The results of this study are not conclusive with regard to the effect of DN on hamstring flexibility. While not statistically significant, the 95% confidence intervals for the between group difference change score for the AKE (-4.66, 9.02) and ASLR (-2.26, 8.48) include a potentially clinically meaningful change. As a result, research investigating muscle flexibility changes associated with DN may warrant further consideration.

Future research is needed to investigate the characteristics of subgroups of the population (acute versus chronic injury, physical/psychosocial attributes) that respond favorably to this intervention and more clearly identify those more likely to experience most favorable outcomes. In addition, DN research should aim to identify optimal treatment parameters and the effectiveness of DN in various body regions and musculoskeletal conditions.

## CONCLUSION

The results of the current randomized controlled trial suggest that two sessions of DN and daily stretching did not result in larger improvements in hamstring ROM, pain, and self-reported function compared to daily stretching and sham DN, over one week, in a young active population with atraumatic knee pain. Although potentially relevant within-group changes were observed, it is unclear whether these changes were a result of treatment or merely the result of passing time. Additional research is needed to more clearly define the effects of DN on tissue flexibility for different body regions as well as to identify subgroups of the population more likely to obtain optimal outcomes following DN intervention.

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