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Effect of Adding Hamstring Muscle Dry Needling to Rehabilitation Protocol After Anterior Cruciate Ligament Reconstruction on Knee Mobility

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Abstract:

Background: Anterior cruciate ligament (ACL) injury is among the most popular injuries among adult population. Knee range of motion (ROM) deficits are more commonly complain following anterior cruciate ligament reconstruction (ACLR) surgery. It has been found that dry needling for hamstring muscles improves muscle flexibility and decreases muscle tightness.

Purpose: To assess the combined effect of hamstring dry needling with the rehabilitation protocol after ACLR on knee flexion and extension ROM.

Methods: Forty participants were enrolled (males and females) in this study after ACLR (semitendinosus tendon autograft) and their age range from 18-35 years old. Group A (n=20): Participants received traditional ACLR rehabilitation protocol. Group B (n=20): Participants received hamstring dry needling added to traditional ACLR rehabilitation protocol. Knee flexion and extension ROM were measured by using digital goniometer. Unpaired t-test, Chi square, Shapiro-Wilk and Kolmogrov-Smirnov, and MANOVA were used for data analysis.

Results: no statistically significant differences were found in the mean values of knee extension ROM at 5th weeks, 3rd month and 5th month between both groups (p=1, 0.917 and 0.914, respectively). Moreover, no statistically significant differences were found in the mean values of Knee flexion ROM at 5th weeks, 3rd and 5th month between both groups (p=0.660, 0.943 and 0.913, respectively).

Conclusions: In terms of improving knee flexion and extension range of motion, adding hamstring muscle dry needling to the traditional rehabilitation protocol following ACLR was not more effective than the traditional rehabilitation protocol alone.

Keywords: Anterior cruciate ligament reconstruction; range of motion; myofascial trigger points dry needling

1. Introduction

Among the most common ligamentous injuries in the knee is an injury to the ACL, its incidence was reaching 68.6 per 100,000 in general population every year, it is common among males than females in general population, its maximum incidence occur in adults aged group 19-25 years. (Sanders et al., 2016). There is upcoming increased incidence of ACL injuries among middle aged individuals and athletes. Injuries of the ACL leads to in increased knee joint laxity, and knee instability and dysfunction (Herrington & Fowler.,2006). When a rupture of the ACL occurs, an individual has activity participation, which in turn lowers their knee quality of life. Additionally, it raises the possibility of developing secondary osteoarthritis (OA) in the knees later on (Monk et al., 2016).

Anterior cruciate ligament reconstruction (ACLR) is a frequent surgical technique to allow injured subject to return to their common active lifestyle. Rehabilitation after ACLR is important for the successful return to high demand cutting and jumping activities (Wright et al., 2008). One of the common problems after ACLR rehabilitation is regaining the complete knee extension range of motion (ROM), it was found that 25.3% of subjects after ACLR have an extension lag and loss of extension ROM at 4th week after surgery (Mauro et al., 2008). The first goal to be attained after ACLR is to regain active as well as passive knee extension equal to the opposite knee at 1st week after surgery (Mauro et al.,2008), extension lag that occurs in the initial stage after ACLR surgery is caused by hamstring muscle shortening that is characterized by firm palpable fibers in the hamstring muscles (Guerra-Pinto et al.,2017). Subjects with knee extension lag also had decreased quadriceps muscle tone. Subjects with absent complete extension ROM always has abnormal gait patterns due to exaggerated knee flexion during loading response and midstance in gait cycle, quadriceps weakness, patellofemoral joint pain, and fatigue. (Mauro et al., 2008).

Hyperirritable spots within skeletal muscle called myofascial trigger points (MTrPs) are linked to a sensitive nodule in a tight fiber of muscle tissue. It is proposed that MTrPs are the main cause of pain in 30 - 85% of people with musculoskeletal disorders. The MTrPs seem to be associated with shortening of length sarcomeres and affect the process of central and peripheral sensitization, the evidence of applying dry needling to deactivate MTrPs is increasing in the last years. Dry needling (DN) was of value in the short term for pain relief, regaining ROM and improve quality of life when compared to no treatment or sham or placebo. (Espejo-Antúnez et al., 2017). Trigger point dry needling (TrP-DN) technique was shown to be an effective treatment when added to the rehabilitation program of ACLR patients suffering from myofascial pain syndrome, reducing pain intensity, improving knee flexion ROM, in addition to enhancing the mechanical properties of the quadriceps muscle throughout late phase of rehabilitation (Ortega et al.,2016). Hamstring muscles dry needling was detected to be beneficial in improving muscle flexibility in comparison to with sustained stretch, one treatment session using DN could be an effective technique for improving hamstring tightness along with flexibility (Unverzagt et al.,2020).

So, the current study was done to assess the combined impact of hamstring DN to rehabilitation protocol after ACLR on knee flexion and extension ROM.

Materials and Methods

The study was a double blinded randomized controlled study in which participants after ACLR were randomized, utilizing an internet bases random generator (www.graphpad.com), into one of two treatment groups: group (A) received traditional ACLR rehabilitation protocol, group (B) received hamstring muscles dry needling combined with traditional ACLR rehabilitation protocol. The study intervention was started from the 1st week after surgery, until the end of the 5th month after surgery. Participants completed study assessment at three time points: (1) after 5th post operative week, (2) after 3rd post operative month, (3) after 5th post operative month. The outcome measures were knee flexion and extension ROM.

This study was conducted to compare the impacts of combining hamstring muscle DN to traditional protocol versus traditional protocol alone after ACLR regarding flexion and extension ROM deficit as assessed passively by digital goniometer. It was done at the outpatient clinic of faculty of physical therapy in Pharos University, Alexandria, Egypt. the ethical committee at Cairo University's faculty of physical therapy gave their approval to the study (P.T.REC/012/003776).

Participants: Forty-seven participants were enrolled (males and females) after ACLR (semitendinosus muscle tendon autograft) and their age range from 18-35 years old. All participants were referred by orthopedic surgeon whom was responsible for diagnosis of the ACL injury based on clinical and radiological examination and he has done ACLR semitendinosus tendon autograft surgery. Group A (n=20): (18 males, 2 females) with mean age of 25.3±4.7and mean BMI of 25.3±2, Group B (n=20): (18 men, 2 women) with a mean age of 28 ±5.3and mean BMI of 26.2±3.8 **(Table 1)**, seven individuals were excluded from participation as they didn't fulfill the eligibility criteria as illustrated in flow chart **(Figure 1)**.

Inclusion Criteria: Forty participants (Both gender) with ACLR according to the sample calculation test, Age of participants ranged from 18-35 years, Participants who underwent ACLR (autograft of the semitendinosus muscle tendon) one-week post-operative **(Ohta et al., 2003). Exclusion Criteria** (Brandner et al., 2018, DePhillipo et al., 2018): The individuals were excluded from this study if they have one of the following: unstable graft, Active infection, postsurgical excessive knee effusion after surgery, ACL reconstruction using any other type of graft, unstable cardiovascular disease, any lower extremity traumatic event, hip and ankle conditions, BMI more than 30 kg/m^2 or pregnancy.

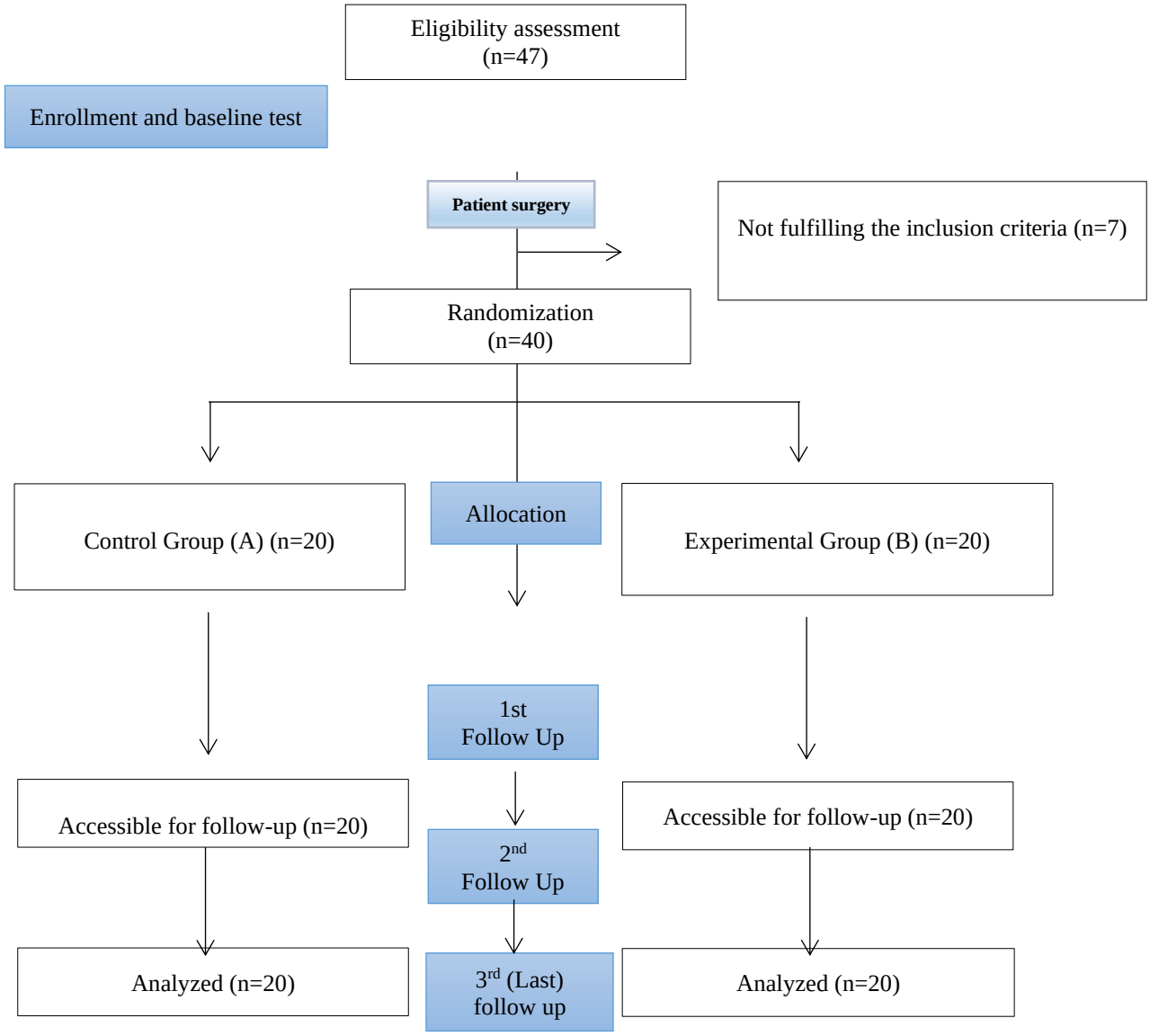


Figure (1). flow diagram showing the flow of patients throughout the trial.

Instrumentation:

1. Universal scale for height, weight as well as body mass index (BMI)

Figure (2). Universal scale

2. **Digital Goniometer For Knee ROM Assessment**

There are a variety of valid and reliable tools that can measure the ROM in the knee, including conventional goniometers, smartphone apps, as well as digital goniometers. One of the most accurate methods to evaluate knee angles was with a digital inclinometer **(Hancock et al., 2018).**

When compared to the universal goniometer, the digital goniometer had sufficient intra-rater reliability and sufficient concurrent criterion-related validity for evaluating joint ROM (**Carey et al., 2010**).

3. **Dry needles**

Thin filiform needle is used to penetrate the skin.

Figure (3). dry needles

Procedures for assessment:

Knee flexion and extension ROM were measured using digital goniometer, all participants were evaluated three times: after 5th post-operative week, after 3rd post-operative month and after 5th post-operative month, the femur's axis is located among the greater trochanter's center as well as the lateral epicondyle, while the tibia's axis lies among the lateral femoral epicondyle as well as the center of the lateral malleolus (Hancock et al.,2018).

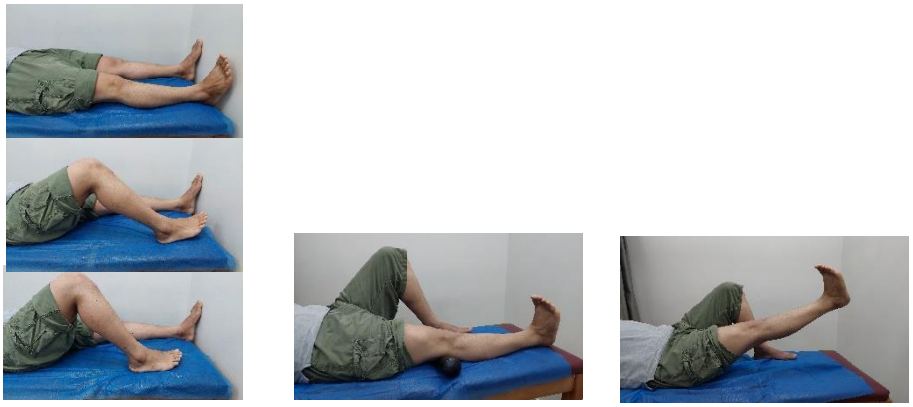
Procedures for treatment:

All participants were enrolled into one of two groups after one week post ACLR surgery, all participants started traditional rehabilitation program immediately after surgery (3 times a week). Based on the exercise protocol from **(Kevin et al., 2017; Adams et al., 2012).**

Group A (Control group):

All participants started ACLR rehabilitation program after operation. The participants visit the clinic three visits per week.

Immediate postoperative phase (1st Week): the goal in this phase is to regain full passive knee extension ROM, decrease joint effusion and pain, regain patellar mobility, gradually increase knee flexion ROM, attain quadriceps control as well as regain independent gait, exercises utilized in this phase to achieve previous mentioned goals is quadriceps set exercises, heel slide exercise and straight leg raise exercise. **(Figure 4)**



heel slide **quadriceps sets** **straight leg raise**

Figure (4).

Early rehabilitation phase (2th-5th week): the goal in this phase is to keep full passive knee extension ROM, improve knee flexion ROM, reduce the remaining effusion and pain, enhance muscle control and activation and regain proprioception and neuromuscular control.

Intermediate postoperative phase (6th-8th Week): the goal in this phase is to enhance lower limb strength, proprioception, balance, neuromuscular control, as well as muscular endurance, progressive strengthening/neuromuscular control. Exercises used in this phase to achieve previous mentioned goals is wall sets, free squat. **(Figure 5)**

Wall set free squat

Figure (5).

Late phase (9th-12th weeks): throughout this stage, we aimed to restore normal strength in the lower extremities, enhance muscle endurance, as well as neuromuscular control.

Group B (Experimental group):

Participants started rehabilitation programs after operations as mentioned in control group, first dry needling session was conducted one week post operative, the patient lay in the prone position to allow access to the posterior thigh, one session of TrP-DN was conducted every week on the most hyper-algesic active trigger point of the hamstring muscle of the operated side **(Velázquez-Saornil ET AL.,2017).** The participant placed in a relaxed position appropriate for exposing the muscles being needled. Then the triggered point identified using palpation method according to the trigger point chart as illustrated in figure (6) (Huguenin.,2004). It involves inserting a disposable, excellent solid filament needle either directly into the skin or through a guide tube, which is subsequently removed. The needle needs to be inserted deeply enough to get into the trigger point (Unverzagt et al.,2015).

Figure: (6). hamstring muscle dry needling

Statistical Analysis: Mean ± SD was used to express the data. Subject characteristics from the two groups were compared using chi-square as well as an independent t-test. The data distribution was tested for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests. The effects of the parametric variables (Knee ROM) were compared using MANOVA, both within and between the groups. Data analysis was carried out using SPSS Inc.'s (Chicago, Illinois, USA) Statistical Package for the Social Sciences, version 20 for Windows. A p-value of 0.05 or lower was regarded as statistically significant.

Results:

The demographic data of the participants in both groups did not show any difference. Both groups' demographics are summarized in Table (1). pre-treatment, the groups' mean ± standard deviation (SD) values for age, weight, height, along with BMI are displayed. No differences were found between the groups ($p>0.05$). When comparing the groups based on operated side as well as side dominance, a chi-square test found no statistically significant differences.

Table 1: Patients' demographics including age, weight, height and BMI values, for the both tested groups at **Table (1): Demographic data of participants of both groups**

Demographic data	Group A	Group B	t-value	p-value
Age (years)	25.3±4.7	28 ±5.3	-1.73	0.091
Weight (kg	78.7±6.8	79.3±9	-0.238	0.813
Height (cm)	176.5±6.5	174.6±7.9	0.810	0.423
BMI (kg/m^2)	25.3±2.1	26.2±3.8	-0.931	0.360
Operated side Right Left	Number (%) 15 (75%) 5 (25%)	Number (%) 14 (4570%) 6 (30%)	$\chi^2 = 0.125$	0.723
Dominant side Right Left	 17 (85%) 3 (15%)	 18 (90%) 2 (10%)	$\chi^2 = 0.229$	0.633

Data is expressed as mean ± standard deviation and number (%), χ^2: chi square.

a. Knee Extension ROM:

Within group comparison: Group A: The mean ± SD of knee extension ROM at 5th week, 3rd month and 5th month in group A was 0.35 ± 1.9, -0.55 ± 1.6 and -1.5 ± 1.4^{O} respectively. The

percentage of change between 5th and 5th month was 528%. There was a statistically significant increase in mean values of Knee extension ROM (p = 0.001).

Group B: The mean ± SD of Knee extension ROM at 5th week, 3rd month and 5th month in group B was 0.35 ± 1.7, -0.5 ± 1.4 and -1.45 ± 1.5O respectively. The percentage of change between 5th and 5th month was 514%. There was a statistically significant increase in mean values of knee extension ROM (p = 0.001)

Between groups comparison: There was no statistically significant difference in the mean values of Knee extension ROM at 5th week, 3rd month and 5th month between both groups (p=1, 0.917 and 0.914).

Post-hoc test between measurements for Knee extension ROM: As observed in table (3), post hoc test for Knee extension ROM of the three measuring values in groups A and B revealed that; there was statistically significant difference between 5th week and 3rd month (P = 0.001) in favor to 3rd month, between 5th week and 5th month (P = 0.001) in favor to 5th month and between 3rd month and 5th month (P = 0.001) in favor to 5th month.

b. Knee Flexion ROM:

Within group comparison: Group A: The mean ± SD of knee flexion ROM at 5th week, 3rd month, and 5th month in group A was 136.4 ± 5.2, 138.1 ±4.4 and 138.4 ± 4.6O respectively. The percentage of change between 5th week and 5th month was 1.5%. There was a statistically significant increase in mean values of Knee flexion ROM (p = 0.001). **Group B:** The mean ± SD of Knee flexion ROM at 5th week, 3rd month, and 5th month in group B was 137.1 ±4.8, 138.2 ± 4.3 and 138.5 ± 4O respectively. The percentage of change between 5th week and 5th month was 1%. There was a statistically significant increase in mean values of Knee flexion ROM (p = 0.018).

Between groups comparison: There was no statistically significant difference in the mean values of Knee flexion ROM at 5th week, 3rd month, and 5th month between both groups (p=0.660, 0.943 and 0.913)

Post-hoc test between measurements for knee flexion ROM: As shown in table (3), post hoc test for Knee flexion ROM of the three measuring values in group A revealed that; there was statistical significant difference between 5th week and 3rd month (P = 0.005) in favor to 3rd month, between 5th week and 5th month (P = 0.001) in favor to 5th month, while there was no statistical significant difference between 3rd month and 5th month (P = 0.542). Post hoc test in group B revealed that; there was no statistically significant difference between 5th week and 3rd month (P = 0.117), between 3rd month and 5th month (P = 0.359), while there was no statistically significant difference between 5th week and 5th month (P = 0.028) in favor to 5h month.

Table (2): Mean ±SD of Knee ROM measures of both groups

Measured variables	Group A Mean ±SD	Group B Mean ±SD	f-value	P-value (between groups)
Knee extension ROM (degrees)				
5th week	0.35 ± 1.9	0.35 ± 1.7	0	1
3rd month	-0.55 ± 1.6	-0.5 ± 1.4	0.011	0.917
5th month	-1.5 ± 1.4	-1.45 ± 1.5	0.012	0.914
% of change	528%	514%		
P-value (between measures)	0.001	0.001		
Knee flexion ROM (degrees)				
5th week	136.4 ± 5.2	137.1 ±4.8	0.196	0.660
3rd month	138.1 ±4.4	138.2 ± 4.3	0.005	0.943
5th month	138.4 ± 4.6	138.5 ± 4	0.012	0.913
% of change	1.5%	1%		
P-value (between measures)	0.001	0.018		

SD: standard deviation, ROM: range of motion, % of change: between 5th week and 5th month, F-value: value of MANOVA, P- value: significance

Table (3): Post-hoc test between measurements for Knee ROM, for both groups

Post hoc between measurements for adherence		Knee extension		Knee flexion	
		Group A	Group B	Group A	Group B
5th week vs. 3rd month	Mean difference	0.9	0.85	-1.65	-1.1
	P-value	0.001	0.001	0.005	0.117
5th week vs. 5th month	Mean difference	1.85	1.8	-1.9	-1.4
	P-value	0.001	0.001	0.001	0.028
3rd month vs. 5th month	Mean difference	0.95	0.95	-0.3	-0.35
	P-value	0.001	0.001	0.542	0.359

Discussion

This study was performed to examine the impact of adding hamstring muscle DN on traditional rehabilitation protocol after ACLR on knee joint mobility. Findings showed that knee extension and flexion ROM improved in both groups, while no significant difference were found among both groups at follow-up periods (5^{th} week, 3^{rd} month and 5^{th} month after surgery).

Dry needling has safe and great effect in releasing myofascial trigger points, it is regarded as an invasive method for treating myofascial pain. Neurophysiological effect and mechanism of action of dry needling should be known, it was suggested that myofascial trigger points have aneural connection and is integrated in the spinal cord via a myofascial trigger points circuit, when needle is inserted in the trigger point it elicit local twitch response which has an effect on the distribution of the myofascial trigger points circuit and decreasing dorsal horn neuronal activity **(Jiménez-Sánchez et al.,2022)**

One characteristic of muscles that affect their flexibility and performance is stiffness, the application of dry needling is thought to help in regulating muscle tone and decreasing hypertonia through modifying muscle stiffness and viscoelastic properties. **(De Meulemeester et al.,2017)**

The study results came in agreement with that shown in a previous work conducted by **Geist et al (2017)** in which the authors measure the clinical effect of hamstring muscle dry needling on healthy individuals, twenty seven individuals where randomly classified into two groups, control group which received blunt needling and experimental group which has received two dry needling session with 3-5 days interval in between, hamstring extensibility, performance and 4 unilateral hop tests were measured, it has been included that hamstring muscle dry needling does not help in increasing muscle flexibility. They proposed that as presence of hamstring muscle myofascial trigger point has been linked to decreased hamstring flexibility which would directly affect knee ROM especially knee extension ROM.

The study results came in agreement with the results shown in a work conducted by **Mason et al (2016)** in which they conducted a single blinded randomized control trial on 44 subacute patients with ACLR of complete ACL rupture, twenty two participants received traditional protocol of rehabilitation after ACL reconstruction (control group) and twenty two participants received quadriceps vastus medial DN in addition to the traditional rehabilitation protocol, pain intensity and ROM were assessed. It was concluded that Quadriceps vastus medialis DN when added to rehabilitation protocol in subacute patients after ACLR would increases ROM only immediately after the DN application or maximum for one week which could be considered a temporary short-term effect, but they found that the dry needle application has no long-term effect.

The results of the study did not come in agreement with the results shown in a work conducted by **Alaei et al (2020)** who performed a randomized controlled trial to compare the effect of hamstring muscles DN and static stretch exercise on hamstring flexibility in healthy individuals with hamstring tightness. Forty healthy participants were enrolled in the study, participants were

randomly classified into two equal groups, the DN group was given one session of dry needling on 3 points of the hamstring muscles, each for 1 minute, while one session of static hamstrings stretching exercise has been applied to the 2nd group, involving of 3 sets of 30-second static hamstring stretch with a 10-second rest between sets, hamstring flexibility and knee extension ROM were improved in the dry needling group after 15 minute of the intervention than static stretch group. There was a difference in results as the authors measure the short-term impact of the dry needling technique, which was 15 minutes after the application, but in that study the first outcome measures were taken after 5 weeks of the application, which may recommend further researches to identify the effect of hamstring muscle dry needling on knee ROM in the rehabilitation protocol post ACLR at different time frames.

The study results did not come in agreement with the results shown in a work conducted by **Velázquez et al** (2017) who evaluated the effect of dry needling on vastus medialis in a rehabilitation protocol after ACLR, which also assess the short-term impact of dry needling on joint pain, knee ROM, function, and stability. The outcome measures were taken immediately 2 hour,1week, 5 weeks after the dry needling treatment, they proposed that dry needling vastus medialis trigger point in addition to a rehabilitation protocol after ACLR has short term impact on enhancing knee ROM and short- to mid-term effect on function. The difference in results could emerge as quadriceps trigger point release allow the quadriceps muscle to respond quickly for activation and strengthening exercises which allow the participant to maintain the gained ROM during the session (Velázquez et al year of publication). They also have measured the short-term impact of dry needling application and that differs from our study long term follow up periods.

The study results did not come in agreement with the results shown in a work conducted by **Ortega-Cebrian et al (2016)** who examined the impact of DN the quadriceps muscles on pain levels (as measured by VAS during a single-leg step-down) as well as ROM in the knees of 20 active male patients in the advanced phases of ACL rehabilitation. The patients participated in the study if they had anterior thighs or knee pain, and following a clinical examination, they were found to have mild improvements in both pain and ROM following just one session of DN, there was a difference with the study results as the authors has conducted the dry needling on the quadriceps muscle not on hamstring muscle trigger point as conducted in this study, and so when releasing the quadriceps muscle would have direct effect on knee flexion because it is known that quadriceps tightness would directly decrease knee flexion ROM and releasing it will has direct effect on knee flexion ROM.

The study results did not come in agreement with the results shown in a work conducted by **Shah et al (2018)** who conducted his study on 80 athletes post ACL reconstruction. The mean age was 24.8 (ranged between 18-35), their active and passive extension ROM was evaluated 2 weeks (13-15days) post ACLR and one session of hamstring muscle dry needling has been done to release the hamstring muscle and knee ROM has been measured again, significantly improvement in both active and passive range of motion has been reported by the author, A total of 71 patients (88.75%) demonstrated an enhancement in passive ROM, whereas 59 patients (73.75%) demonstrated an

enhancement in active ROM., this disagreement may be due to the author is measuring the short term effect of dry needling not the long term effect.

Up to the authors' knowledge, no study has examined the impact of adding hamstring muscle DN to traditional rehabilitation protocol after ACLR on knee ROM. The study findings showed that there was no superiority of adding hamstring muscle dry needling to traditional rehabilitation protocol in enhancing knee flexion and extension ROM, suggesting that different dry needling techniques should be applied and should be measured at different follow up periods as there was large contradiction and research gape in dry needling application.

Conclusion: In terms of improving knee flexion and extension range of motion, adding hamstring muscle dry needling to the traditional rehabilitation protocol following ACLR was not more effective than the traditional rehabilitation protocol alone.

Recommendations:

• Additional studies needed to determine the effectiveness of hamstring muscle dry needling when combined with other types of therapeutic modalities used to release myofascial trigger point.

• Additional studies are needed to determine the effectiveness of hamstring muscle dry needling on knee extension ROM in other musculoskeletal problems.

- Additional studies are required to examine the effectiveness of quadriceps muscle dry needling after ACLR

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