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effect of quadratus lumborum dry needling on gluteus medius force, patellofemoral joint pain and function in patellofemoral pain

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Abstract

Objective: To compare the effects of conventional treatment alone and combined with quadratus lumborum dry needling on maximal isometric force of the gluteus medius, knee pain and function in patients with patellofemoral pain syndrome.
Patients and Methods: Participants with patellofemoral pain syndrome (N=56) were randomly assigned to intervention (conventional +dry needling) and control (conventional) groups. Both groups underwent conventional physiotherapy for 6 sessions (three times a week for 2 weeks). Besides the above intervention, the intervention group underwent quadratus lumborum dry needling for 3 sessions. Pain (Visual analog scale), function (Kujala score) and maximal isometric force of gluteus medius were recorded at baseline, immediately after the first and sixth session. Analysis of variance (2groups*3times) was used to compare within- and between-group differences.
Results: At baseline, no variable showed significant differences between groups (P>0.05). The six-session treatment led to a significant reduction in pain intensity and function and improvement of maximal isometric force of gluteus medius in both groups compared to baseline and immediately after the first session (p <0.05). However, there were no significant differences in all variables immediately after the first session compared to baseline (P>0.05). The intergroup comparison showed no significant differences in all variables between two groups after six sessions.
Conclusions: The current study shows that conventional physiotherapy combined with quadratus lumborum dry needling cannot lead to a further reduction in pain and improvement of maximal isometric force of the gluteus medius and function in individuals with patellofemoral pain syndrome.

Keywords: *Patellofemoral Pain Syndrome; Myofascial Pain Syndromes; Dry Needling; Gluteus medius; Quadratus lumborum*

Introduction

Patellofemoral pain syndrome(PFPS) is one of the most common knee problems[1]. The prevalence of PFPS has been reported as between 15-45% of the population[2]. Females are more likely to develop PFPS compared to men[3]. PFPS is mainly characterized by diffuse retropatellar and peripatellar pain that is aggravated by loading the patellofemoral joint during weight-bearing on a flexed knee[1].

There is a general agreement that the etiology of PFPS is multifactorial, including structural factors that are directly related to patellofemoral joint and surrounding tissue and mechanical elements in foot and ankle and hip and pelvis as the distal and proximal factors[4].

Gluteus medius (GM) dysfunction or inhibition may be associated with excessive hip adduction and internal rotation and poor control of pelvic, causing greater dynamic knee valgus and lateral patellar tracking and subsequent PFPS[4]. GM provides pelvic stability in the frontal plane during the gait cycle[5]. Quadratus lumborum(QL) is one of the deep trunk muscles that cooperate with GM in order to maintain the pelvic balance during standing and walking[6]. If GM does not have enough force, the result is compensatory gait and the center of mass will shift laterally over the weakened hip[7]. Female runners with PFPS indicated more hip adduction and internal rotation and they had a greater tendency to ipsilateral trunk lean compared to the healthy population[8]. In individuals with PFPS, there is greater ipsilateral trunk lean and hip adduction during single-leg squat[9]. Those studies show that ipsilateral trunk lean is concomitant with QL activation to maintain a level pelvis during single-leg standing or dynamic exercises[10]. In response to dysfunction or inhibition of GM as a phasic muscle, QL, which is the synergy of GM and a

postural muscle, is prone to become overuse and overactive[11].

There is consensus that muscle overuse can lead to the development of myofascial trigger points. [12]. They have unpredictable effects on motor function and normal motor activity in a muscle.[13, 14]. The muscle that hosts a latent myofascial trigger point, has several motor alterations. They are characterized as within - and between-muscle [15-17]. between-muscle alterations comprise an increase in the activity of synergistic muscles with latent myofascial trigger points[16]. Subjects with PFPS have a higher prevalence of latent trigger points in QL muscle compared with healthy population[18] causing inhibition and insufficiency of GM[13, 14].

There are various treatments for trigger points including injection therapy, dry needling (DN), massage, ultrasound and Transcutaneous electric nerve stimulation (TENS) [19]. DN, which is performed with a fine filiform needle that is used to penetrate the skin and target underlying trigger points, has become a popular treatment technique in recent years[20]. This technique has neurophysiological, mechanical and chemical effects on muscles[21]. Several studies focused on the effectiveness of DN in PFPS management.[22-24] To our knowledge, no study has previously investigated the effects of QL DN on GM maximal isometric force, knee pain and function in people with PFPS.

Therefore, the objective of this study was to compare the effects of conventional treatment alone and combined with QL DN on maximal isometric force of the GM, knee pain and function in patients with PFPS. We hypothesized that individuals receiving conventional treatment combined with QL DN would exhibit greater improvements in GM maximal isometric force, knee pain and function than those receiving only conventional treatment.

MATERIALS & METHODS

Study design

This study was a parallel-group single-blind randomized clinical trial with an allocation ratio of 1:1. It was approved by the local ethics committee of Isfahan medical university (IR.MUI.RESEARCH.REC.1398.570) and the trial was prospectively registered in the Iranian clinical trial database as IRCT20200113046113N1. Recruitment and data collection occurred between March and October 2020. The sample size calculation was based on previous similar study[23], assuming an alpha level of 0.05, a beta level of 0.2, a standard deviation of 2.2 and a least significant difference of 1.7. The sample size was determined to be 26 subjects in each group. Of the 61 volunteers, 52 participants who met the inclusion and exclusion criteria were enrolled by a physiotherapist. All volunteers were informed about the objectives of the study, and they signed an informed-consent form prior to their participation in the study, which was approved by the local ethics committee. Given a block size of 4 and the number of 14 blocks, 26 participants were randomly assigned to each group. All allocations were placed in sealed opaque envelopes and a different person opened the envelope and proceeded with treatment assignment. The physiotherapist and participants in each group were blinded to group allocations until the treatment was started. Outcomes were assessed by a clinician blinded to group assignment.

Participants

After being diagnosed with PFPS, patients were referred to the clinics in Isfahan, Iran. They were screened for eligibility criteria at a physiotherapy clinic. To be included in this trial, patients had to have: (1) unilateral prepatellar or retropatellar pain with gradual onset and unrelated to trauma for at least 3 months; (2) pain at least during two of following activates of prolonged sitting, stair climbing, squatting, running, jumping or hopping; (3) age between 18 and 40 years; (4) visual analog scale score higher than two; (5) ability to read and write.

Individuals were excluded if they had: (1) a history of ligaments (collaterals and cruciate) or meniscus damage; (2)a history of patellar dislocation or positive apprehension test; (3) knee joint effusion; (4) a history of hip or lumbar referred pain; (5) previous surgery to the patellofemoral joint; (6) history of nonsteroidal anti-inflammatory drug or corticosteroid use; (7) Known articular cartilage damage (from previously obtained imaging); (8) history of regular physical activity; (9) leg length discrepancy; (10) hip adductor tightness; (11) neurological low back pain; (12) Contraindication for DN, such as inflammation or active infection, blood disease, anticoagulation therapy, fear of needles, pregnancy.

Interventions

In this study, one group received conventional physiotherapy (control group) and the other received the same treatment in combination with DN for ipsilateral QL muscle (Intervention group). All participants received 6 sessions, three times per week, during the treatment protocol of the study (two weeks). Each session lasted 30 to 35 minutes (five more minutes for DN in the intervention group). Treatments were performed by a physiotherapist with 9 and 5 years of clinical experience in physiotherapy and DN respectively.

Both groups received the same conventional physiotherapy program in the form of TENS (stimulator733X, novin medical engineering, Iran) and strengthening exercises[25]. The exercise program consisted of straight leg raise and single leg squats and side-lying hip abduction. This program was taught to patients in the first treatment session and monitored during each session to ensure that exercises were done correctly. Participants were asked to perform straight leg raise with 10 s hold and 10 s rest and repeat this exercise for 7 and half minutes. The duration of Single leg squats and rest time was

depended on the patient's ability, but the ratio should be 1: 1 and this was repeated for 7 and a half minutes. Two mentioned exercises were performed at the clinic for the strengthening of quadriceps femoris muscle. Subjects were asked to perform side-lying hip abduction with 10s hold and 10s rest and repeat this exercise twice a day, 15 times at home to promote GM activation[26]. The TENS was used and four electrodes were applied around the patella, which was fixed by two straps. Each patient received 15 minutes of sensory TENS after exercises for pain-relief. Parameters were a pulse duration of 150 ms with a frequency of 100 Hz.

Patients allocated to intervention also received DN in the ipsilateral QL muscle at first, third and fifth sessions. DN was performed with 0.3*60 mm disposable stainless-steel needles (Dong Bang, Seoul, South Korea). Treatment was started by washing hands, using latex-free examination gloves and preparing the patient's skin with alcohol. Patients were asked to lie on the uninvolved side and raising the arm of the affected side to the top of the table, behind the head and a pillow placed under the trunk to improve access to the muscle. The region between the 12th rib and iliac crest was identified. Next, the fingers were placed slightly posterior and pressed deeply with flat palpation to identify the lateral border of the QL muscle. Then the needle was directed straight down toward its attachments at the transverse process of L4. After that, the entire muscle was explored by slight anterior, posterior, and caudal needling. It was applied according to the fast-in and fast-out technique[14].

Outcome measures

All three outcome measures (average knee pain intensity, knee functional performance and maximal isometric force of GM) were measured before (baseline), immediately after the first session and after the sixth session by a physiotherapist who was blinded to treatment allocation.

The visual analog scale is an appropriate and reliable scale for clinical and experimental evaluation of pain intensity[27]. The score ranges from 0, with no pain, to 10, indicating the most severe pain imaginable. Participants were instructed to score their perceived pain on this scale at baseline, immediately after the first session and after the sixth session.

The Persian version of Kujala questionnaire, a valid and reliable measurement tool, was used to evaluate subjective functional performance[28]. The scores range from a maximum of 100 to a minimum of 0, higher scores indicating lower levels of pain and disability.

Handheld dynamometer was used to measure Isometric force of hip abductor. Participants were positioned in side-lying on a treatment table while symptomatic limb was above and maintained in a neutral position by placing a pillow in between the participant's knees. A strap was used to stabilized the patient's trunk and pelvis by placing it inferior to the iliac crest and strong fastening around the underside of the table. The Handheld dynamometer (Bio-feedback Electrotherapy kit, Model Rehabkit, NCC Medical Co, Shanghai, China) was positioned 5 cm proximal to the tibiofemoral joint line. An immovable strap was pulled through the dynamometer and secured around the plinth (fig 1). The subjects were verbally encouraged to produce a maximum voluntary isometric contraction by pushing the thigh upward with maximal effort for 7 seconds. The maximal force was generated 2 seconds and maintained for an additional 5 seconds. One practice trial and three test trials were completed by participants with a 15-second rest period between trials. The peak output of the three trials was used for maximum hip abduction isometric force. All measured forces were recorded in kilogram. Then these forces were normalized to the participant's body weight in order to compare correctly[18]. Acceptable level of interrater reliability was reported for handheld dynamometer measurement of hip abduction strength[29]. Prior to the beginning of the data collection, a test-retest study was conducted to establish the intrarater reliability of the measures for the assessor. 15 subjects were tested on two sessions separated by 24 hours.

Figure 1. testing position for hip abduction isometric force

Statistical analysis

Descriptive and statistical data were analyzed by SPSS version 24. The 1-sample Kolmogorov-Smirnov test was used to confirm normal distribution of the data for all variables. Baseline demographic and clinical variables were compared between both groups using independent t-tests for continuous data and chi-square tests of independence for categorical data. Analysis of variance with repeated measures (2 groups*3 times) was used to compare within- and between-group differences for investigating the effect of the intervention on the maximal isometric force, knee pain and function. The time variables were baseline, immediately after the first session and after the sixth session, and the group variables were the intervention group and the control group. Bonferroni correction was used to adjust for multiple pairwise comparisons. The *P* value of <0.05 was considered to be statistically significant. To determine Intra rater reliability for measuring maximal isometric force by dynamometer, Pearson correlation coefficient and ICC calculation were used.

RESULTS

Participants

Out of 61 volunteers, 52 were eligible and participated in this study; 26 participants were randomized into each group. None of the subjects withdrew from the study, and all 26 of them in each group received the allocated intervention and data for all participants were included in the analysis (fig 2). Demographics characteristics and variables measured at the baseline are presented in table 1 and no statistically significant changes were found in demographic and baseline variables between two groups. With the exception of minimal soreness, which was reduced during the next visit, no adverse events were reported in any of the groups.

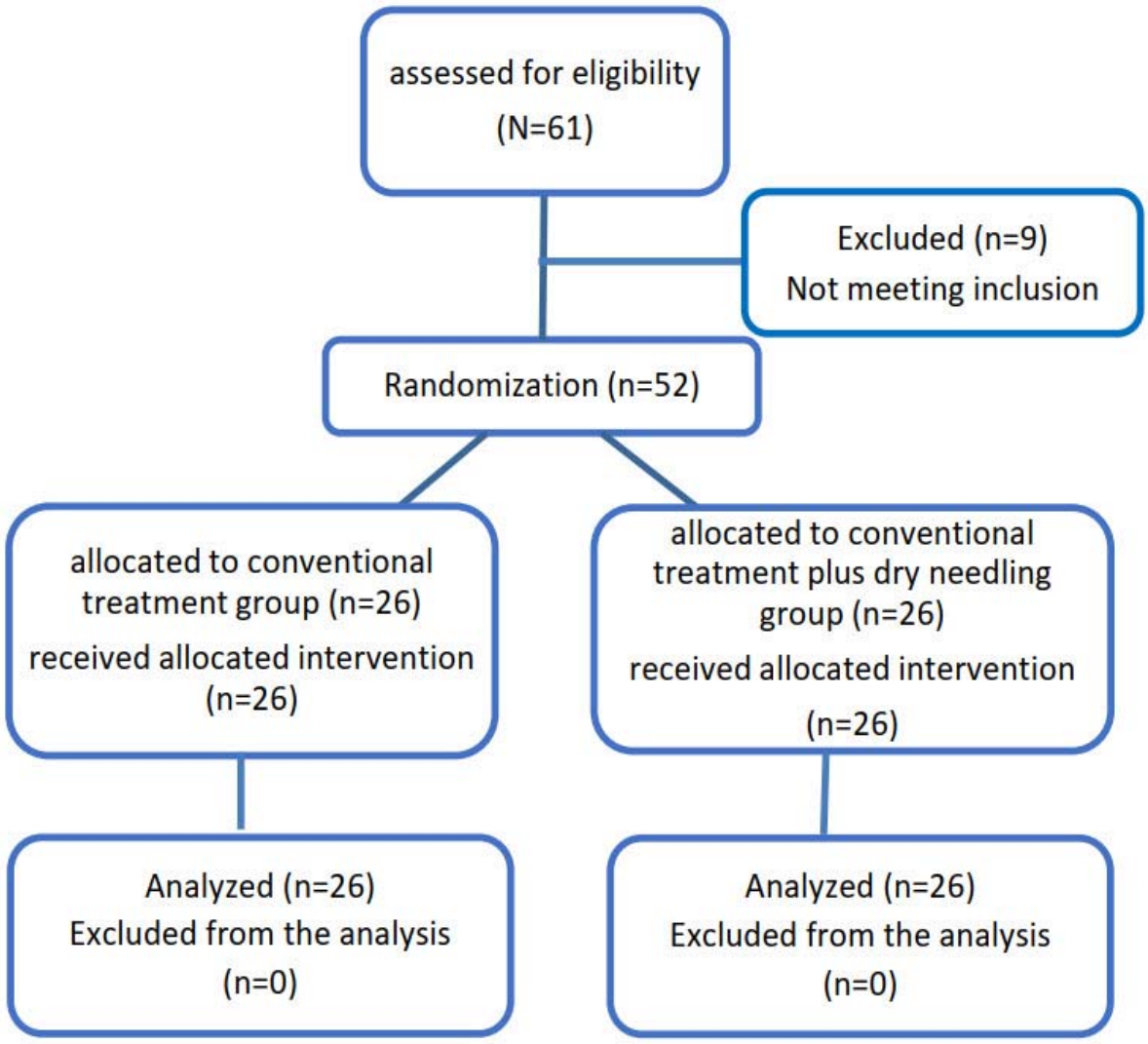

Figure 2. flow diagram of patients throughout the course of the study

Table1 Participant characteristics at baseline by treatment assignment		
Parameter	Intervention group (n=26) mean±SD	Control group (n=26) mean±SD
Age, y	35.46±6.04	33.35±5.73
Weight, kg	71.94±13.30	69.00±14.61
Sex, n (%) Male Female	 8 (30.8) 18 (69.2)	 7 (26.9) 19 (73.1)
Side of knee pain, n (%) Right knee Left knee	 13 (50) 13 (50)	 14 (53.8) 12 (46.2)
Dominant limb, n (%) Right side Left side	 17 (65.4) 9 (34.6)	 17 (65.4) 9 (34.6)
VAS † (0-10)	6.88±1.36	6.35±1.44
Kujala score (0-100)	64.50±15.13	66.31±15.77
MIF ‡, %	8.04±2.76	9.16±2.95
Abbreviation: † VAS, visual analog scale; ‡ MIF, maximal isometric force gluteus medius.		

Outcomes

Comparisons of the baseline and immediately after the first session versus sixth session measures showed significant improvements in pain, Kujala score and maximal isometric force of GM in both groups (all, *P=0.001)* (table 2,3,4). Comparison of the baseline versus immediately after the first session showed no significant changes in all outcomes in both groups (P>0.05) (table 2,3,4).

Comparison between groups showed that there was no significant difference and both groups showed a similar pattern of change in all variables. *P* values of interaction and intervention were not significant for all outcomes (Table 2,3,4).

Intrarater reliability for maximum hip abduction isometric force was excellent, with ICC values (95%confidence interval) of 0.94 (0.85 -0.98) and Cronbach's alpha of 0.97.

Table 2 Comparison of the mean scores for the maximal isometric force between intervention and control groups in the baseline, immediately after the first session and the sixth session						
Group	Baseline (mean±SD)	Immediately after the first session (mean±SD)	sixth session (mean±SD)	*P* value time	*P* value intervention	*P* value interaction
Intervention	8.04± 2.76	7.97 ± 2.86	9.43 ± 3.06	0.001	0/3	0.485
Control	9.16 ± 2.95	8.37 ± 2.18	10.17 ± 3.26	0.001		
P value	0.166	0.57	0.408			

Table 3 Comparison of the mean scores for function between intervention and control groups in the baseline, immediately after the first session and the sixth session

Group	Baseline (mean±SD)	Immediately after the first session (mean±SD)	sixth session (mean±SD)	*P* value time	*P* value intervention	*P* value interaction
Intervention	64.50 ± 15.13	64.50 ± 15.13	73.77 ± 14.34	0.001	0.814	0.363
Control	66.31 ± 15.77	66.31 ± 15.77	73.15 ± 18.75	0.001		
P value	0.675	0.675	0.895			

Table 4 Comparison of the mean scores for pain between intervention and control groups in the baseline, immediately after the first session and the sixth session

Group	Baseline (mean±SD)	Immediately after the first session (mean±SD)	sixth session (mean±SD)	*P* value time	*P* value intervention	*P* value interaction
Intervention	6.88 ± 1.36	6.88 ± 1.36	4.15 ± 2.20	0.001	0/183	0.830
Control	6.35 ± 1.44	6.35 ± 1.44	3.50 ± 2.55	0.001		
P value	0.173	0.173	0.327			

DISCUSSION

This randomized clinical trial found that QL DN cannot improve the maximal isometric force of GM and knee pain and function in people with PFPS and no significant differences were detected between groups. The results showed that no outcomes changed immediately after the first session compares with baseline. However, all evaluated variables improved at the sixth session compared to baseline and immediately after the first session in both groups.

In line with previous studies, our result supports the effectiveness of hip external rotator and abductor and knee extensor strengthening exercises on improving function and relieving pain in subjects with PFPS[30, 31]. Open and close kinematic chain exercises can have beneficial effects on patellar stabilization and are recommended for treatment of these patients[32]. In consequence, both groups in the current trial benefited from exercise therapy during two weeks of the treatment protocol.

Previous studies investigated the effects of quadriceps DN on pain and function in patients with PFPS[22, 23]. To the best of the author's knowledge, the only study that used DN for hip and trunk muscle was research that conducted by Zarei et al[24]. They found that adding QL and GM DN to exercise therapy had beneficial effects on pain and function in individuals with PFPS. However, their results are not comparable with the results of our study because they used DN for contralateral QL in contrast with our clinical trial that used DN for ipsilateral QL.

Clinical reasoning for the application of DN for ipsilateral QL in the present study was based on the hypothesis that trigger points in this muscle can inhibit GM, which is weak in patients with PFPS. We hypothesized that individuals receiving QL DN combined with conventional treatment would exhibit greater improvements in GM maximal isometric force, knee pain and function. However, the results of this clinical trial did not confirm that hypothesis.

Our findings are consistent with those from other studies. Pérez-Palomares et al identified that shoulder muscles DN does not affect lateral abduction strength in individuals with shoulder pain[33]. Furthermore, a study demonstrated that a single session of infraspinatus DN has no effect on the power of grip in older adults with_nonspecific shoulder pain[34]. A recent systematic review and meta-analysis involving a wide range of studies showed that needling therapies do not affect muscle force production[35]. However, the comparison to previous studies was difficult because none of them used DN for a muscle and investigated effects on its synergy. In addition, the present study is the first to integrate DN and

TENS (as a conventional treatment) and evaluate muscle force production.

One possible explanation for our results may be related to the use of TENS align with DN. Anterior knee pain causes abnormal afferent sensory information[36]. Abnormal afferent sensory information can lead to the reduction of the excitability of the α-motor neuron and cause quadriceps and GM inhibition[37, 38]. Park et al found that experimental knee pain alters neuromuscular function and causes GM inhibition during landing[38]. In this current study, TENS was used because of its physiologic effects on pain perception[39]. TENS treatment increases motor neuron pool excitability of quadriceps femoris and can also disinhibit this muscle in people with experimental knee pain[40]. One possible interpretation of these results may be the activation produced by TENS in GM. Therefore, the tone of QL decreased and the force of GM improved. However, no study has yet investigated the effects of TENS on GM maximal isometric force in people with PFPS. We suggest future studies investigate the disinhibitory effects of TENS on GM in people with PFPS and compare the effect with DN. Further, patients assigned to the study group received 3 sessions DN, as to the best of our knowledge, there is no scientific data on adequate frequency and dose of DN. We can mention that the more DN sessions, the more between-group differences.

Study limitations

The results of this trial should be considered according to some potential limitations. First, we had no conventional + placebo group, so individuals were not blind to the treatment with DN. Second, we had a small sample size and greater number of subjects would lead to better outcomes. Third, the function of GM was not investigated. The benefits of the QL DN on GM may be revealed if we measured GM function in the current trial. Finally, it should be considered that this study was concurrent with the pandemic of coronavirus that makes trouble for participants to participate in the study and researchers to conduct the study.

Conclusion

QL DN combined with conventional treatment, did not result in better outcomes in maximal isometric force of GM and knee function and pain in individuals with PFPS and both groups showed similar improvement in all outcomes.

Declaration of conflicting interests

The authors state that they have no conflicts of interest.

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Authors' Contributions

F.A.N., F.M. and M.J.T. are responsible for the conception and design of the study. F.M. and O.N. collected the data and wrote an initial draft. M.H., N.T. and F.A.N. read and revised the article critically for important intellectual content. M.J.T analyzed the data. All authors contributed to the interpretation of data and reviewed and approved the final version of the article accepted for publication.

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References

1. Neal BS, Lack SD, Lankhorst NE,et al. Risk factors for patellofemoral pain: A systematic review and meta-analysis. Br J Sport Med 2019; 53: 270–81.
2. Smith BE, Selfe J, Thacker D, et al. Incidence and prevalence of patellofemoral pain: A systematic review and meta-analysis. PloS one 2018;13: :e0190892.
3. Willy RW, Hoglund LT, Barton CJ, et al. Patellofemoral pain. J Orthop Sports Phys Ther 2019;49:CPG1–95.
4. Chan ZYS, Zhang JH, Au IPH,et al. Gait retraining for the reduction of injury occurrence in novice distance runners: 1-year follow-up of a randomized controlled trial. Am J Sports Med 2018;46:388–95.
5. Caldas R, Mundt M, Potthast W,et al. A systematic review of gait analysis methods based on inertial sensors and adaptive algorithms. Gait & posture 2017;57:204-10.
6. Jairakdee Y, Chansirinukor W and Sitti T. Effect of releasing quadratus lumborum muscle on hip and knee muscle length in asymptomatic individuals. J Bodyw Mov Ther 2021; 26: 542-7.
7. Neumann, Donald A., Elisabeth Roen Kelly,et al. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation. 3rd ed. St. Louis: Elsevier; 2017.
8. Dix J, Marsh S, Dingenen B, et al. The relationship between hip muscle strength and dynamic knee valgus in asymptomatic females: A systematic review. Phys Ther Sport 2019; 37: 197–209.
9. Wilczyński B, Zorena K, Ślęzak D. Dynamic knee valgus in single-leg movement tasks. Potentially modifiable factors and exercise training options. A literature review. Int J Environ Res Public Health 2020;17:8208.
10. Kowalchuk S. Constraining kinematics during single-leg squats and step-ups can reduce quadratus lumborum activation and facilitate gluteal activation (dissertation). Ontario: Western Ontario Univ.; 2016.
11. Chaitow L, Franke H. Muscle energy techniques. 3 rd ed. Edinburgh: Churchill Livingstone; 2013.
12. Bron C and Dommerholt JD. Etiology of myofascial trigger points. Curr Pain Headache Rep 2012; 16: 439-44.
13. Ahmed S, Haddad C, Subramaniam S,et al. The Effect of Electric Stimulation Techniques on Pain and Tenderness at the Myofascial Trigger Point: A Systematic Review. Pain Med 2019; 20: 1774–88.
14. Dommerholt J, Fernández-de-las-Peñas C. Trigger point dry needling : an evidence and clinical-based approach. 2 nd ed. Amsterdam: Elsevier; 2018.
15. Barbero M, Falla D, Mafodda L, et al. The location of peak upper trapezius muscle activity during submaximal contractions is not associated with the location of myofascial trigger points. Clin J Pain 2016; 32: 1044-52.
16. ernández-de-Las-Peñas C, Dommerholt J. International consensus on diagnostic criteria and clinical considerations of myofascial trigger points: a Delphi study. Pain Med 2018;19:142–50.
17. Rahou-El-Bachiri Y, Navarro-Santana MJ, Gómez-Chiguano GF, et al. Effects of trigger point dry needling for the management of knee pain syndromes: a systematic review and meta-analysis. J Clin Med 2020;9:2044.

18. Roach S, Sorenson E, Headley B,et al. Prevalence of myofascial trigger points in the hip in patellofemoral pain. Arch Phys Med Rehabil 2013; 94: 522-6.
19. Kang JJ, Kim J, Park S,et al. Feasibility of Ultrasound-Guided Trigger Point Injection in Patients with Myofascial Pain Syndrome. Healthcare 2019; 7: 118.
20.Dommerholt J. Dry needling—peripheral and central considerations. J Man Manip The 2011; 19: 223-7.
21. Dommerholt J. Dry needling in orthopedic physical therapy practice. Orthop Phys Ther Pract 2004; 16: 15-20.
22. Behrangrad S, Abbaszadeh-Amirdehi M, Kordi Yoosefinejad A,et al. Comparison of dry needling and ischaemic compression techniques on pain and function in patients with patellofemoral pain syndrome: a randomised clinical trial. Acupunct Med 2020: 0964528420912253.
23. Espí-López GV, Serra-Añó P, Vicent-Ferrando J, et al. Effectiveness of inclusion of dry needling in a multimodal therapy program for patellofemoral pain: a randomized parallel-group trial. J Orthop Sports Phys Ther 2017; 47: 392-401.
24. Zarei H, Bervis S, Piroozi S,et al. Added Value of Gluteus Medius and Quadratus Lumborum Dry Needling in Improving Knee Pain and Function in Female Athletes With Patellofemoral Pain Syndrome: A Randomized Clinical Trial. Arch Phys Med Rehabil 2020; 101: 265-74.
25. Manojlović D, Kozinc Ž, Šarabon N. Trunk, Hip and Knee Exercise Programs for Pain Relief, Functional Performance and Muscle Strength in Patellofemoral Pain: Systematic Review and Meta-Analysis. J Pain Res 2021; 14:1431-49.
26. Distefano LJ, Blackburn JT, Marshall SW,et al. Gluteal muscle activation during common therapeutic exercises. J Orthop Sports Phys Ther 2009; 39: 532-40.
27. Bennell K, Bartam S, Crossley K,et al. Outcome measures in patellofemoral pain syndrome: test retest reliability and inter-relationships. Phys Ther Sport 2000; 1: 32-41.
28. Negahban H, Pouretezad M, Yazdi MJS, et al. Persian translation and validation of the Kujala Patellofemoral Scale in patients with patellofemoral pain syndrome. Disabil Rehabil 2012; 34: 2259-63.
29. Piva SR, Fitzgerald K, Irrgang JJ, et al. Reliability of measures of impairments associated with patellofemoral pain syndrome. BMC Musculoskelet Disord 2006; 7: 1-13.
30. Emamvirdi M, Letafatkar A, Khaleghi Tazji M. The effect of valgus control instruction exercises on pain, strength, and functionality in active females with patellofemoral pain sndrome. Sports Health 2019; 11: 223–37.
31. Hott A, Brox JI, Pripp AH,et al. Effectiveness of isolated hip exercise, knee exercise, or free physical activity for patellofemoral pain: a randomized controlled trial. Am J Sports Med 2019; 47:1312–22.
32. Alsaleh SA, Murphy NA, Miller SC, ,et al. Local neuromuscular characteristics associated with patellofemoral pain: A systematic review and meta-analysis. Clin Biomech 2021; 90: 105509.
33. Pérez-Palomares S, Oliván-Blázquez B, Pérez-Palomares A, et al. Contribution of dry needling to individualized physical therapy treatment of shoulder pain: a randomized clinical trial. J Orthop Sports Phys Ther 2017; 47: 11-20.
34. Calvo-Lobo C, Pacheco-da-Costa S and Hita-Herranz E. Efficacy of deep dry needling on latent myofascial trigger points in older adults with nonspecific shoulder pain: a randomized, controlled clinical trial pilot study. J Geriatr Phys Ther 2017; 40: 63.
35. Mansfield CJ, Vanetten L, Willy R,et al. The effects of needling therapies on muscle force production: a systematic review and meta-analysis. J Orthop Sports Phys Ther 2019; 49: 154-70.
36. Devrimsel G, Metin Y, Serdaroglu Beyazal M. Short-term effects of neuromuscular electrical stimulation and ultrasound therapies on muscle architecture and functional capacity in knee osteoarthritis: a randomized study. Clin Rehabil 2019;33:418–27.
37. Zacharias A, Pizzari T, Semciw AI, et al. Comparison of gluteus medius and minimus activity during gait in people with hip osteoarthritis and matched controls. Scand J Med Sci Sports 2019; 29: 696–705.
38. Park J, Denning WM, Pitt JD,et al. Effects of experimental anterior knee pain on muscle activation during landing and jumping performed at various intensities. J Sport Rehabil 2017; 26: 78-93.
39. Hay C, Ismail F. The effect of manipulation versus TENS in the treatment of muscle inhibition of the quadriceps muscle in patients with knee osteoarthritis (dissertation). Johannesburg: Johannesburg Univ. ; 2020.
40. Hopkins JT, Ingersoll CD, Edwards J, et al. Cryotherapy and transcutaneous electric neuromuscular stimulation decrease arthrogenic muscle inhibition of the vastus medialis after knee joint effusion. J Athl Train 2002; 37: 25.