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Manual ischemic compression in patients with Patellofemoral pain syndrome

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Abstract

Background: The presence of trigger points in the quadriceps muscle is considered one of the most important causes of patellofemoral pain syndrome (PFPS). Manual ischemic compression has been reported to be effective in treating trigger points. **Objective:** This study was done to investigate the effect of manual ischemic compression on quadriceps trigger points in patients with PFPS. **Methodology:** Thirty males and females patients aging between 25-40 years old participated in this study. They were assigned randomly into two equal groups; experimental group (group A) consisted of 15 patients who received manual ischemic compression on quadriceps trigger points and the conventional physical therapy program (hot packs, patellar mobilization, and quadriceps strengthening exercises). The control group (group B) consisted of 15 patients who received the conventional physical therapy program only. They got three visits a week for five weeks.All participants were assessed at the baseline and after 15 sessions. Pressure algometer and the Arabic version of Kujala patellofemoral score were used tomeasure pressure pain threshold and functional disability, respectively. **Results:** The results showed that the experimental group showed statistical significant reduction of pain and functional disability.**Conclusion:** Manual ischemic compression was effective in reducing the signs and symptoms of PFPS by treating the quadriceps trigger points and could be used as a rehabilitation intervention for patient with PFPS.

Keywords

Patellofemoral pain syndrome- Ischemic compression- Triggers points-Pain.

Introduction

Patello femoral pain syndrome (PFPS) is the most neglected, the least known and the most problematic pathological knee condition **(Arazpour et al. 2016).** The presence of trigger points in quadriceps muscle was considered one of the important causes of this problem **(Roach et al. 2013)**.

Patellofemoral pain syndrome can be defined as retropatellar or peripatellar pain resulting from physical and biomechanical changes in the patellofemoral joint and can be considered one of the most common conditions of knee pain anteriorly, affecting both athletes and sedentary subjects **(de Moura Campos Carvalho-E-Silva et al.,2016)**. Pain is most prominent when ascending or descending stairs, squatting, or sitting for prolonged periods with the knees flexed. PFPS is the most common diagnosis in patients complaining of knee pain **(Servodio Iammarrone et al., 2016, Lankhorst et al., 2012 and Kim and Chang, 2012)**. It tends to occur more frequently in young adults. The incidence of PFPS is reported to be between 15% and 25% **(Kwon et al., 2014 and Nunes et al., 2013)**.

In a study of subjects with PFPS, **Suter et al., (1998)** demonstrated the quadriceps femoris (QF) muscle inhibition was closely associated with PFPS. About 95% of subjects with PFPS have active and/or latent myofascial trigger points (TrPs) of the QF muscle. The presence of TrPs in QF could result in retro- or peripatellar pain, muscle weakness and loss of full muscle lengthening leading to inhibition of the QF muscle activity and a resultant extensor mechanism dysfunction**.** The TrPs of the QF are located below the anterior inferior iliac spine and at the lower end of the muscle just above the patella **(Chaitow and DeLany, 2002).** Trigger points are also located at the distal end of the vastus medialis superomedial to the patella and at mid-thigh level **(Travell and Simons, 1983).**

TrPs in the QF muscle are extremely common and frequently overlooked, but their findings are based on clinical experience and not clinical trials **(Travell and Simons, 1983)**. An active trigger point can be described as a focus of hyperirritability in a muscle or its fascia that is symptomatic with respect to pain. It refers to a pattern of pain at rest and/or at motion that is specific for the muscle. It is always tender, prevents full lengthening of a muscle, weakens the muscle, mediates a local muscle twitch and often produces specific autonomic phenomena, generally in its referral zone **(Travell et al., 1999 and Murphy, 1989).** A latent trigger point is only painful when palpated and may have all the other clinical characteristics of an active trigger point **(Travell et al., 1999)**.

The choice of treatment seems to be based more on personal preference than on clinical evidence **(Anderson, 1997)**. TrPs could be employed for the treatment of PFPS and their benefits may alter some of the current treatment methods as well as alleviate the trauma, costs and complications of surgical intervention. Ischemic compression has been used as a treatment modality for trigger points.

Long-term treatment approach involves different strategies, including tibiofemoral mobilization, strengthening lower extremity muscles, non-steroidal anti-inflammatory agents, knee braces, taping the patella in position, and orthotics when the condition is due to dysfunction in the foot, such as flat feet (**Lantz et al., 2016, Kuru et al., 2012, and Browne, 2008)**.

Ischemic Compression is a therapy technique used in physical therapy, where blockage of blood in an area of the body is deliberately made, so that a resurgence of local blood flow will occur upon release and it is called trigger point therapy (TPT)**.** Sustained pressure is usually applied to a trigger point with a tolerable amount of pain, and as discomfort is reduced, additional pressure is gradually given **(Montanez-Aguilera et al., 2010).** However, there is lack of research about its clinical effectiveness. Therefore, this study was done to investigate the effect of manual ischemic compression on quadriceps trigger points in patients with PFPS.

Methodology

Study Design; randomized controlled trial, two groups pre-test post-test design was applied in this study.

Subjects; All participants were asked to sign an informed consent form before commencing the study approved by the Ethics Committee. This study was conducted at the Outpatient Clinic of Mansoura Health Insurance Hospital, Egypt from March 2014 to September 2014. Patient received three sessions per week for five weeks. 30 patients (male and female) suffering from PEFS were allocated randomly to one of two groups by a researcher who was blinded in measurement and treatment. Age of patients ranged between 25 and 40 years.

Group A (experimental group) consisted of 15 patients who received manual ischemic compression to the pre-determined trigger points in the QF and the conventional physical therapy program which consists of hot packs **(Simons and Travell, 1999)**, patellar mobilization **(Stakes et al., 2006; and Rowlands and Brantingham, 1999), quadriceps** strengthening exercise, hamstring stretching exercises **(Laprade et al., 1998; and Roush, 2000)** and activity modification **(Simons and Travell, 1999)**. Group B (control group) included 15 patients who received the same conventional physical therapy program that patients in group A received.

Inclusion criteria: Patients complained of pain during ascending stairs, squatting, running, kneeling, cycling or during sitting with knees flexed for long periods of time. They had pain on patellar palpation. These symptoms were for at least 12 months and had insidious onset of symptoms unrelated to a traumatic incident. Age of the patients ranged between 20 to 40 years old.

Exclusion criteria: Patients who had a coexisting pathology or previous surgery or fracture were excluded from the study. Patients who had history of patellar dislocation/subluxation, osteoarthitis of the knee meniscal lesion, ligamentous instability, traction apophysitis around the patellofemoral complex, patellar tendon pathology, chondral damage, osteoarthritis, or referred pain from the spine.

Instrumentations

A) Pressure Algometer:

A simple hand held device was used to measure trigger point tenderness level by determining (PPT) using a pressure transducer probe that was placed on the trigger point. This algometer registered the force (in kilograms per square centimeter) that was recorded as usually the amount of pressure that causes pain, the PPT **(Fischer, 1994)**. The international association for the study of pain (IASP) defined pressure pain threshold as the lowest stimulus that gives rise to the earliest perception of pain in an instructed person under given conditions of noxious stimulation **(Graff-Radford, 2004).**

B) The Kujala Patellofemoral Scoring System:

It is a self-administered, weighted questionnaire that examines 13 domains, including pain and functionality. The score ranges from 0 to 100 with higher scores performing better. It has been commonly used in the assessment of PFPS **(Crossley et al., 2004)**.

It documents response to six activities thought to be associated specifically with anterior knee pain syndrome (walking, running, jumping, climbing stairs, squatting and sitting with knee bent for prolonged periods), as well as symptoms such as limp, inability to weight bear through the affected limb, swelling, abnormal patellar movement, muscle atrophy and limitation of knee flexion. Scoring is hierarchical using various types of categorization including 'no difficulty_ unable' and 'no pain _ sever pain'. Some sections incorporate grading of the distance able to be walked or run without pain. The section on stairs climbing distinguishes those with pain only on descending stairs from those who experience pain both ascending and descending **(Papadopoulos et al., 2016, Kujala et al., 1993)**. The validity of Kujala have been previously demonstrated by **Kujala et al., (1993)**. The Arabic version of Kujala demonstrated excellent reliability and had a very good agreement (ICC = 0.96: 95% CI: 0.93, 0.98) **(Alshehri, 2015).**

Procedures

1) Evaluative procedures

a) The researcher used the Kujala patellofemoral scoring system to record the baseline level of anterior knee pain in half lying position.

c) The specific locations of the trigger points within the QF were determined and noted by permanent markers.

d) Baseline measurements were taken by using pressure algometer for all participants.

e) Level of tenderness of the quadriceps trigger points was measured by the pressure algometer device by obtaining pressure pain threshold value. The tip of the probe of the transducer was applied perpendicular on the trigger point and increasing the pressure 1 kg/cm^2 sec., the exerted pressure was held and gradually increased until the subject tolerance and said "stop" **(Giesbrecht and Battie, 2005)** (as shown in figure1).

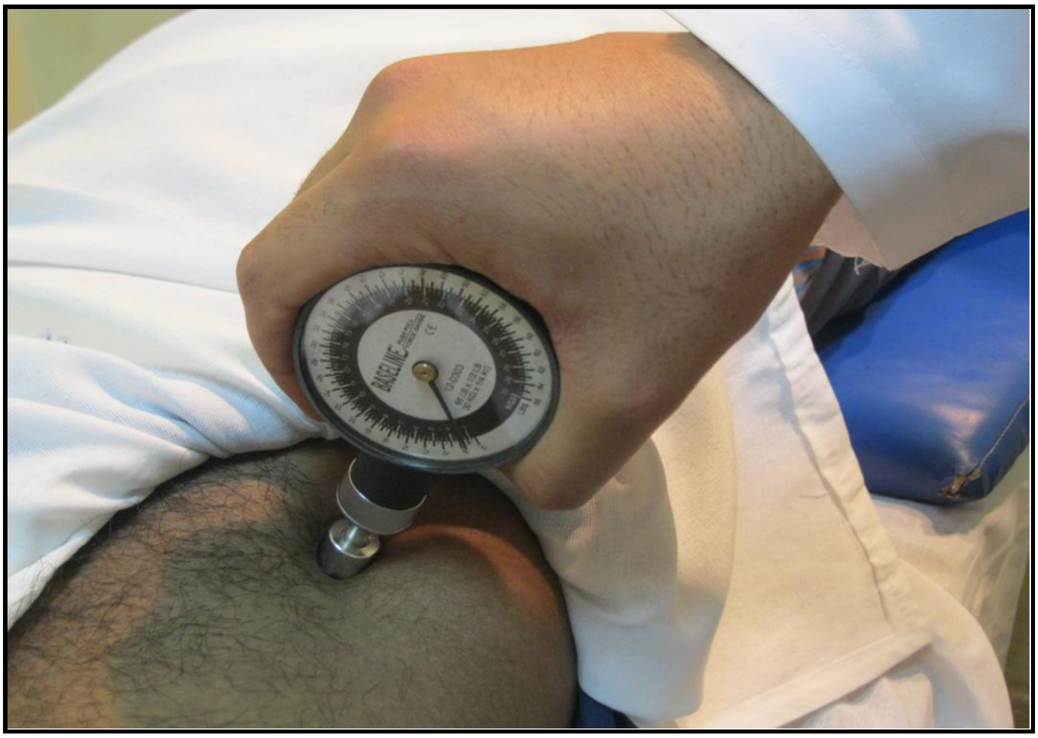

Figure (1): Measurement of level of tenderness of trigger points by pressure algometer.

The specific location of the trigger point within the four muscles, which constitute the QF, was determined and noted by permanent marker as indicated by **Chaitow and DeLany (2002)** as follow:

1-Trigger points in the vastus medialis muscle are usually found close to the medial border of the muscle in the mid belly and at the distal attachment of the muscle (TrP1 and TrP2).

2- Trigger points in the vastus lateralis muscle lie deep in the muscle and are extensively distributed throughout the length of the muscle (TrP3, TrP4, TrP5, TrP6 and TrP7).

3- The vastus intermedius muscle can develop multiple trigger points along its length, deep to the rectus femoris muscle and therefore cannot be directly palpated.

4- The rectus femoris muscle trigger point is located proximally in the muscle close to the anterior inferior iliac spine (TrP8 and TrP9).

2) Treatment Procedures

a) Manual ischemic compression technique: It was done for participants in group (A) by applying digital pressure (one thumb on the other) to every trigger points for 15 seconds and started with light firm pressure and gradually increased it till reaching the patient's maximum pain tolerance (as shown in figure 2). This procedure was repeated 3 to 5 times on each trigger point **(Hains, 2002)**.

Figure (2): Manual ischemic compression technique on TrP.

b) The conventional physical therapy program: it was applied for both groups (A and B).

1) Hot packs for 15 minutes

2) Patellar mobilization: subject was instructed to lie down in half lying position and his/her knees extended then medial and lateral glide of the patella was applied by placing fingers of both hands medially and both thumbs laterally around the medial and lateral borders of the patella, respectively then glide the patella in medial or lateral direction then glide it in the caudal and cephalic direction **(Stakes et al., 2006 and Rowlands and Brantingham, 1999)**.

3) Strengthening exercise (straight leg raising): Patient was instructed to lie down in supine lying position with the affected knee extended and the sound one flexed with its foot rested on the table then patient instructed to first set the quadriceps muscle; then lift the leg to about 45 degrees of hip flexion while keeping the knee extended, hold it for 10sec. then lower and relax it, 30 repetitions in each session **(Al-Hakim et al., 2012).**

4) Hamstring muscles stretching in supine. Each exercise was repeated three times. Each lasted for 30 seconds **(Crossley et al., 2002, Powers, 1998, McConnell, 1996**).

5) Activity modification: Each patient was instructed to stop all activities that aggravate pain or put the patella in maximum compressible force. Activities such as squatting, stair climbing, or prolonged knee flexion were avoided **(Simons and Travell, 1999)**.

Data analysis

Statistical analysis was done using SPSS software version (20). Descriptive statistics were taken for subjects' ages, body weight, height and BMI. Normality of the distribution of the data was investigated using Kolmogrov-Smirnov testing with alpha set at 0.05. Paired t- test was used to compare Kujala score and pressure algometer measurements within ischemic compression and control groups pre-and post-treatment. Independent t-test was also used to detect the differences between the ischemic compression and control groups regarding Kujala score and pressure algometer measurements. Significance level was set at $p<0.05$ for all comparisons.

Results

There was no statistical significant difference between both groups in their ages, weights, height and body mass index (BMI) where their t and P value were (-0.208, 0.687), (-0.929, 0.638), (-2.985, 0.944) and (0.535, 0.213) respectively as shown in table 1.

Table (1): Demographic characteristics of patients of both groups

	Group	Mean	Std. Deviation	t-value	p- value.
Age (years)	Control	30.33	5.53	0.208	0.687
	Experimental	30.73	5.01		
BMI	Control	27.91	3.22	0.535	0.213
	Experimental	27.12	4.74		

P > 0.05= non-significant value

I. Kujala score

1- Comparison between pre and post treatment Kujala score for control group

There was no statistical significant difference of Kujala score assessment between pre-and post-treatment application (t=1.447, p=0.159) as shown in figure 3.

2- Comparison between pre and post treatment Kujala Score for experimental group

There was a statistical significant difference of Kujala scores between pre-treatment and post-treatment scores (t= 6.688, P less than 0.0001) as shown in Figure 3.

Table (2); Comparison between both groups regarding Kujala scale and trigger points algometer measurements

		Kujala	TrP1	TrP2	TrP3	TrP4	TrP5	TrP6	TrP7	TrP8	TrP9
Group A	t- value	6.688	15.8	9.68	7	14.28	14.89	13.3	12.72	15.05	15
	P_value	P less than 0.0001									
Group B	t- value	1.447	3.017	0.685	2.457	4.063	3.94	2.632	3.138	2.153	2.35
	P_value	0.159 NS	0.005	0.5 NS	0.02	0.0004	0.0005	0.01	0.004	0.04	0.02
Group A-B	t- value	0.675	1.348	0.547	0.466	0.691	0.897	1.379	1.331	0.342	0.17
	P_value	P less than 0.0001									

NS; non significant

3- Comparison of Post-treatment Kujala scores between both groups:

There was statistical significant difference in post treatment scores of Kujala scores between both groups (t=6.688, p <0.0001) as shown in figure 3.

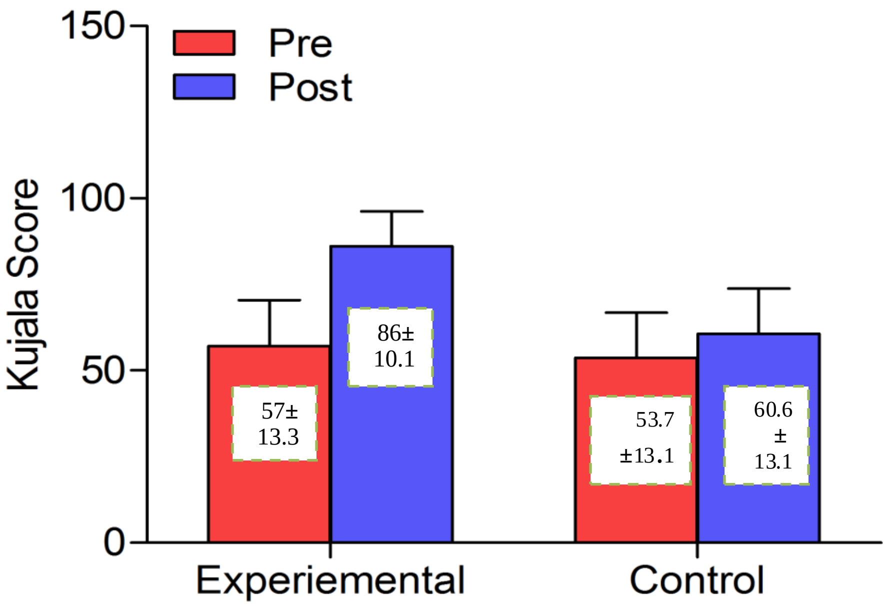

Figure (3): Comparison of Kujala scale between both groups post-treatment (Mean and ±SD)

II. Regarding algometer measurements

1-Comparison between post and pre-treatment algometric readings for control group:

There was not statistical significant difference between post- and pre-treatment readings of pressure in all points as shown in table 2 and figure 4.

2-Comparison between post-and pre-treatment of algometric measurements for experimental group:

There were statistical significant differences between post- and pre-treatment readings of pressure algometer for the level of pressure pain threshold in all points (P less than 0.0001) as shown in table 2 and figure 4.

3-Comparison of post-treatment algometric readings between both groups:

There was statistical significant difference between readings of pressure algometer for the level of pressure pain threshold in all points between the post-test scores of both groups (P <0.0001) as shown in table 2 and figure 4.

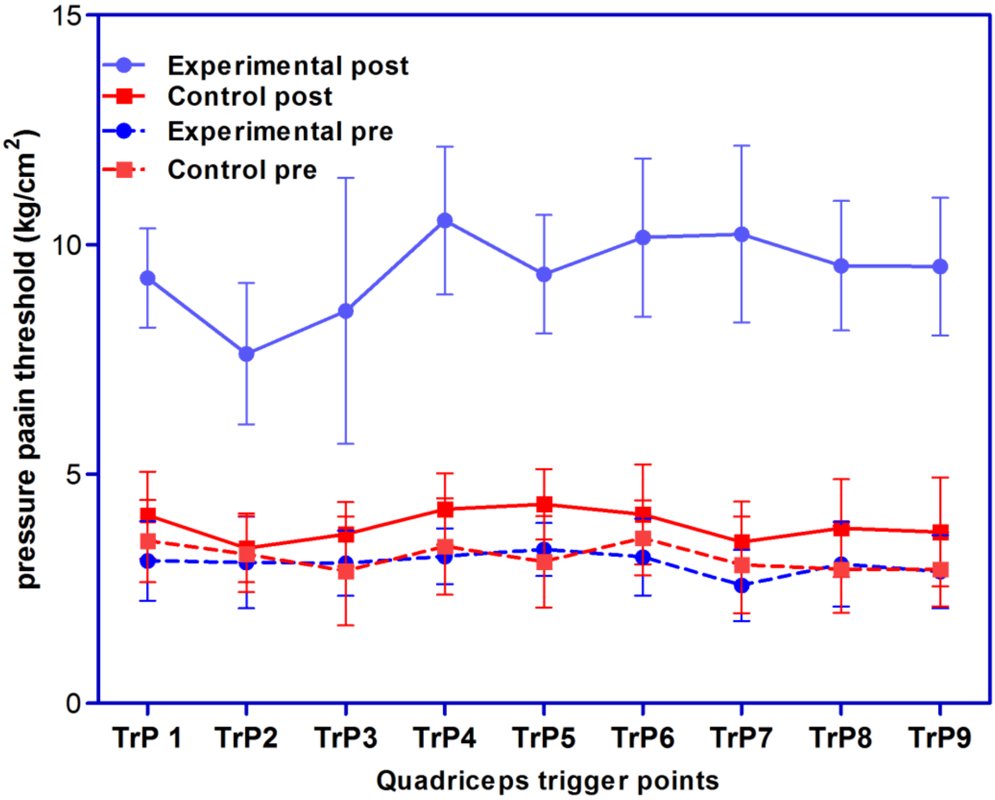

Figure (4): Comparison of algometric measurements between both groups post-treatment (Mean and ±SD)

Discussion

The results of the present study showed that there were statistical significant differences between outcome data obtained from both groups. There were statistical significant differences between post- scores in both groups for the Kujala and algometer scores. Therefore, it was concluded that the first experimental group improved more than the second control group. This could explain that manual ischemic compression combined with the traditional physical therapy in the experimental group appeared to have had a greater effect than the traditional physical therapy alone in control group.

The results of the present study revealed a temporary occlusion of blood flow to this trigger point followed by improvement of the circulation after application of manual ischemic compression technique on trigger points. This can lead to relief of muscle spasm, enhancement of muscle relaxation, decrease of the level of pain. It was also shown that the traditional physical therapy when combined with manual ischemic compression on quadriceps TrPs have significantly improved the functional aspect and the pressure pain threshold of PFPS patients.

The authors used pressure algometer to quantify trigger point pain threshold. **Fischer (1990)** proposed the use of a pressure threshold meter as a means of quantitative documentation of trigger point tenderness, and for quantifying the effects of the treatment. **Graff-Radford (2004)** demonstrated that, although measurements were not precise, differences between trials did not exist.

Algometric measurements have been shown to have good interrater and intra-rater reliability when the measurements were performed once or repeatedly (2-5 repetitions) on a single day, at weekly intervals (1-5 weeks), and at longer intervals (8-12 weeks). This type of instrument is more convenient to use. It has been suggested that this instrument assists in localization of trigger points and determining their level of tenderness **(Graff-Radford, 2004)**.

These finding were supported by many researches **(Heintjes et al., (2009), Kowall et al., (1996), Rickard (2006), Fryer and Hodgson (2005), Travell and Simons (1999), Hains and Hains, (2010),** and **Korthuis (2011))** and opposed with other researches **(Fernandez-de las Penas et al., (2005)** and **Travell and Simons, (1983))**.

Heintjes et al., (2009) did a systemic review to study the effects of effectiveness of exercises on reducing anterior knee pain and improving knee function assessed by the Kujala Patellofemoral score in patients with PFPS. They found that exercise therapy is crucial for the treatment of PFPS which goes with the results of the present study in which the pain and function were improved in the two groups where exercise was part of the two programs.

It has been stated that, exercise has pain reduction effect. However, the effect of exercise is mainly depend on the patients' compliance and still under debate which specific exercise therapy is beneficial **(Servodio Iammarrone et al., 2016, Fukuda et al., 2010, Lee et al., 2010)**. It was found that adding exercises to the conventional physical therapy produce greater improvement in terms of function and pain than conventional physical therapy **(Peters and Tyson, 2013)**. It was also reported that strengthening of the hip muscles has an important role in the treatment of PFPS **(Santos et al., 2015)**. Exercise therapy in cases of PFPS may result in pain reduction and improvement in function **(Van Der Heijden et al., 2016)**.

This study supports the idea that pain in front of the knee is initiated by trigger points in the QF causing a reflex inhibition in it. This is supported by **Kowall et al., (1996)** who stated that the inhibition is due to pain and effusion. It would therefore seem to suggest that the focus of PFPS rehabilitation should begin with treating the trigger points in this muscle and this would then reflexly affect the pain and muscle inhibition experienced in the anterior aspect of the knee and allow for greater improvement in muscular performance once initial inhibitory factors have been removed.

Rickard (2006) looked at some manual interventions in two studies and **Hou et al (2002)** used typical manual treatments of trigger points used by trained physical therapists (ischemic compression). These two studies demonstrated the short-term benefits, but had no long-term follow-up. One of the two studies looked at a combination of heat, range of motion exercises, interferential current, and myofascial release. The other study looked at ischemic compression only and he had demonstrated that the mechanism of pain reduction and softening of the taut pain by manual therapy remains speculative and this support our study that the combination of ischemic compression with traditional physical therapy has beneficial effects than application of the ischemic compression on trigger points.

The present study agreed with **Fryer and Hodgson (2005**) who stated that in evaluating the effectiveness of a commonly used manual technique of trigger point inactivation, trigger point compression by a digital algometer which has been infrequently carried out and demonstrated that there is a benefit of manual compression with pain reduction and an increase in pain pressure threshold.

The result of the present study agreed with **Simons and Travell (1999)** who stated that ergonomic aspects and functional training in the sense of practicing activities of daily living help to reduce poor posture and taking them into account are therefore sensible key components of any myofascial treatment and they have been integrated into the treatment plan for trigger points therapy and are crucial in determining the long term success of TPT. This could explain why some trigger points in the present study in both groups gave statistical non-significant results as some participants might be sedentary or assume bad posture at work or during sleep or driving. Also, participants may have different levels of day to day stress, diet deficiencies and general malnutrition. All these perpetuating factors could re-aggravate trigger points during the period of treatment in the study.

In the study of **Hains and Hains (2010),** they measured the efficacy of ischemic compression to only the peri-patellar and retropatellar regions and reported that some PFT patients demonstrated myofascial trigger point in areas other than the patellofemoral joints. They added that this might contribute to persistent pain in the knee of some patients. That is why we included other distal points away from patellofemoral joint in this study.

The result of the present study agreed with **Korthuis (2011)** who suggested that the ischemic compression is a very effective treatment technique for trigger points, and explained that by "When the arterial inflow to skeletal muscle is suddenly occluded, blood flow decreases and upon removal of the occlusion, skeletal muscle blood flow is markedly enhanced".

In contrast, this study disagreed with the conclusion of **Fernandez-de las Penas et al., (2005)** who stated that there was no rigorous evidence that the application of manual techniques on trigger points have better outcome beyond placebo. The role of manual therapies was neither supported nor refuted by the results of their study. This study suggests that the manual therapy (manual ischemic compression) has an additional improvement effect in treatment of PFPS when combined with traditional physical therapy.

This study disagreed with **Travell and Simons (1983)** who stated that it is misleading to recommend using ischemic compression for trigger point therapy but advocated injection, stretch and spray techniques, and muscle energy techniques for trigger point therapy. They explained this by reporting that it is illogic to treat an area of ischemia by applying additional ischemia.

Ischemic compression may have reduced pain by stimulating the local metabolism, releasing of the vasoactive substances, and reflex vasodilatation after terminating ischemic compression **(Ivanichev, 1990)**.

This study was limited by the small sample size, lack of long term follow up, and the psychological factors which may affect patient response, non-cooperation of some patients. Other limitations include that the pain measurement was limited to pressure algometer, the variability of patient's reaction and their effects on variables.

The duration of treatment for 5 weeks may not have been adequate in the conventional physical therapy group alone to produce significant effects in functional level of the patients. It was reported that function and pain in patients receiving exercise therapy was not significantly different at 3 months, but was statistically significantly better at 12 month duration **(Clark et al., 2000).**

The findings of this study demonstrated that traditional physical therapy when combined with manual ischemic compression on quadriceps trigger points have significantly improved the functional and level of pressure pain threshold. Therefore, manual ischemic compression has been shown to be effective in reducing the signs and symptoms of PFPS by treating the quadriceps trigger point and could be used in rehabilitation intervention for patient with PFPS. These findings suggested that there was significant effect of manual ischemic compression on quadriceps trigger points in patients with PFPS.

Conclusion

Ischemic compression is an effective technique in reducing pain and improving function of knee when combined conventional physical therapy over a period of five weeks.

References

Al-Hakim W., Kumar P., Khan W., and Johnstone D.: The Non-Operative Treatment of Anterior Knee Pain, the Open Orthopaedics Journal; (6):320-9, 2012.

Alshehri AS. Cross-cultural Adaption and Psychometric Properties Testing of The Arabic Anterior Knee Pain Scale, Loma Linda University Electronic Theses, Dissertations & Projects, Doctoral degree , PP 57-63,2015.

Anderson M. The Relative Effectiveness of Cryotherapy versus Moist Heat in the Treatment of Myofascial Trigger Points. M.Tech: Chiropractic dissertation, Technikon Natal, Durban, 1997.

Arazpour M, Bahramian F, Abutorabi A, Nourbakhsh ST, Alidousti A, Aslani H. The Effect of Patellofemoral Pain Syndrome on Gait Parameters: A Literature Review. Arch Bone Jt Surg. 4(4):298-306, 2016

Browner BD. Skeletal Trauma: Basic science, management, and reconstruction. 4th ed. Philadelphia, PA: Elsevier, 2008.

Chaitow L. and DeLany J.W., Clinical Application of Neuromuscular Tequniques.Volume 2 - The Lower Body. Churchill Livingston, Elsevier Science Limited, Edinburgh, Scotland; Pp598. ISBN 0443 06284 6, 2002.

Clark DI, Downing N., Mitchell J., Coulson L, Syzpryt EP, Doherty M: Physiotherapy for anterior knee pain: A randomized controlled trial. Ann Rheum Dis59: 700-704, 2000

Crossley K, Bennell K, Green S, Cowan S, McConnell J. Physical therapy for patellofemoral pain: a randomized, double-blinded, placebo-controlled trial. Am J Sports Med. 30(6):857-65**,** 2002.

Crossley KM, Bennell KL, Cowan SM and Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? Arch Phys Med Rehabil; 85-5:815-22, 2004.

Crossley K., Bennell K., Green S., Cowan S. and McConnell J. Physical therapy for pafellofemoral pain: A randomized, double-blinded, placeb uncontrolled trial. The American Journal of Spans Medicine; 30(6): 857-865, 2002.

de Moura Campos Carvalho-E-Silva AP, Peixoto Leão Almeida G, Oliveira Magalhães M, Renovato França FJ, Vidal Ramos LA, Comachio

J, Pasqual Marques A. Dynamic postural stability and muscle strength in patellofemoral pain: Is there a correlation? Knee. 23(4):616-21**,** 2016.

Fernandez-de-las-Penas C., Campo MS. and Carnero JF. Manual therapies in the myo-fascial trigger point treatment: a systematic review. J Bodyw Mov Ther; 9:27–35, 2005.

Fischer AA. Application of pressure algometry in manual medicine. J Man Med; 5: 145-50, 1990.

Fischer AA.: Pressure algometry (dolorimetry) in differential diagnosis of muscle pain. In: Rachlin ES, editor. Myofascial pain and fibromyalgia: trigger point management. St. Louis (MO): Mosby; p. 121-41, 1994.

Fryer G and Hodgson L the effect of manual pressure release on myofascial trigger points in the upper trapezius muscle. J Body Mov Ther 9:248–255, 2005.

Fukuda TY, Rossetto FM, Magalhães E, Bryk FF, Garcia Lucareli PR, de Almeida Carvalho NA. Short- term effects of hip abductors and lateral rotators strengthening in females with patellofemoral pain syndrome: a randomized controlled clinical trial. Journal of Orthopedic & Sports Physical Therapy. 40(11):736-42, 2010.

Giesbrecht RJS, Battie' MC. A comparison of pressure pain detection thresholds in people with chronic low back pain and volunteers without pain. Phys Ther; 85:1085-1092, 2005.

Graff-Radford S. Myofascial pain: diagnosis and management. Curr Pain Headache Rep; 8:463-7, 2004.

Hains G, and Hains F. Patellofemoral pain syndrome managed by ischemic compression to the trigger points located in the peri-patellar and retro-patellar areas: A randomized clinical trial. Clinical Chiropractic · 13(3):201-209**,** 2010.

Hains G. Locating and treating low back pain of myofascial origin by ischemic compression. J Can Chirop Assoc; 46(4):257—64, 2002.

Heintjes E., Berger M., Bierma-Zeinstra S., Bernsen R. Exercise therapy for patellofemoral pain syndrome .Cochrane Database of Systematic Reviews;1-43, 2009**.**

Herrington L. and Payton C.J. Effects of corrective taping of the patella on patients with patellofemoral pain syndrome. Physiotherapy; 83(11): 566-571, 1997.

Hou CR, Tsai LC, Cheng KF, Chung KC, Hong CZ. Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. Arch Phys Med Rehabil; 83:1406-14, 2002.

Ivanichev GA. Painful Muscular Hypertonus and Trigger Points. Kazan MedicalUniversity, Kazan, 1990.

Kim H, Chang HS.: Comparison of the VMO/VL EMG ratio and onset timing of VMO relative to VL in subjects with and without patellofemoral pain syndrome. J Phys Ther Sci, 24: 1315–1317, 2012**.**

Korthuis R.J. Skeletal Muscle Circulation 3rd ed. San Rafael (CA), Morgan and Claypool Life Sciences, 2011.

Kowall G.M., Kolk G., Nuber G.W., Cassisi J.E. and Stern S.H. Patellar Taping in the Treatment of Patellofemoral Pain. The American Journal of Sports Medicine, 24(1): 61-66. 1996.

Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M and Nelimarkka O.Scoring of patellofemoral disorders. Arthroscopy; 9-2:159, 1993.

Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. Arthroscopy. 9(2):159-63, 1993.

Kuru T, Yalıman A, Dereli EE. Comparison of efficiency of Kinesio® taping and electrical stimulation in patients with patellofemoral pain syndrome. Acta Orthop Traumatol Turc. 46(5):385-92, 2012.

Kwon O, Yun M, Lee W.: Correlation between intrinsic patellofemoral pain syndrome in young adults and lower extremity biomechanics. J Phys Ther Sci, 26: 961–964, 2014.

Lankhorst NE, Bierma-Zeinstra SM, van Middelkoop M.: Risk factors for patellofemoral pain syndrome: a systematic review. J Orthop Sports Phys Ther, 42: 81–94, 2012.

Lantz JM, Emerson-Kavchak AJ, Mischke JJ, Courtney CA. Tibiofemoral joint Mobilization in the successful management of patellofemoral pain syndrome: a case report. Int J Sports Phys Ther. 11(3):450-61, 2016.

Laprade J, Culham E and Brouwer B. Comparison of five isometric exercises in the recruitment of the vastus medialis oblique in persons with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther.; 27:197–204, 1998.

Lee S-P, Souza RB, Powers CM. The influence of hip abductor muscle performance on dynamic postural stability in females with patellofemoral pain. Gait & Posture. 36(3):425-9, 2012.

McConnell J. Management of patellofemoral problems. Man Ther. 1(2):60-6, 1996.

Montanez-Aguilera FJ., Valtuena-Gimeno N., Pecos-Martin D., Arnau-Masanet R., Barrios-Pitarque C. and Bosch-Morell F. Changes in a patient with neck pain after application of ischemic compression as a trigger point therapy. Journal of Back and Musculoskeletal Rehabilitation; 23(2), 101–104, 2010.

Murphy G.J. Myofascial Trigger Points. Journal of Clinical Orthodontics; 23:627-631, 1989.

Nunes GS, Stapait EL, Kirsten MH, et al.: Clinical test for diagnosis of patellofemoral pain syndrome: systematic review with meta-analysis. Phys Ther Sport, 14: 54–59, 2013

Papadopoulos C, Constantinou A, Cheimonidou AZ, Stasinopoulos D.

Peters JSJ, and Tyson N L, Proximal Exercises Are Effective In Treating Patellofemoral Pain Syndrome: A Systematic Review. Int J Sports Phys Ther. 8(5): 689–700, 2013**.**

Powers CM. Rehabilitation of patellofemoral joint disorders: a critical review. J Orthop Sports Phys Ther. 28(5):345-54, 1998.

Rickard LD. the effectiveness of non-invasive treatments for active myofascial trigger point pain: a systematic review of the literature. Int J Osteopathic Med 9:120–136, 2006.

Roach S, Sorenson E, Headley B, San Juan JG. Prevalence of myofascial trigger points in the hip in patellofemoral pain. Arch Phys Med Rehabil. 94(3):522-6, 2013.

Roush M. Anterior knee pain: a clinical comparison of rehabilitation methods. Clin J Sports Med.; 10:22–28, 2000.

Rowlands B.W. and Brantingham J.W. The efficacy of patella mobilization in patients suffering from patellofemoral pain syndrome. Journal of the Neuromusculoskeletal System; 7:142-149, 1999.

Santos TR, Oliveira BA, Ocarino JM, Holt KG, Fonseca ST. Effectiveness of hip muscle strengthening in patellofemoral pain syndrome patients: a systematic review. Braz J Phys Ther. 19(3):167-76, 2015

Servodio Iammarrone C, Cadossi M, Sambri A, Grosso E, Corrado B, Servodio Iammarrone F. Is there a role of pulsed electromagnetic fields in management of patellofemoral pain syndrome? Randomized controlled study at one year follow-up. Bioelectromagnetics. 37(2):81-8, 2016.

Simons D and Travell J. Myofascial Pain and Dysfunction: The Trigger Point Manual, vol 1, 2nd ed. Baltimore: Lippincott Williams & Wilkins, pp 133, 170; 1999.

Stakes N, Myburgh C, Branting ham J, Moyer R, Jensen M and Globe G. A. prospective randomized clinical trial to determine efficacy of combined spinal manipulation and patella mobilization compared to patella mobilization alone in the conservative management of patellofemoral pain syndrome. J Am Chiropr Assoc; 43:11-8: 2006.

Suter, E., Herzog, W., De Souza, K. and Bray, R. Inhibition of the Quadriceps Muscle in Patients with Anterior Knee Pain. Journal of Applied Biomechanics; 14:360-373, 1998.

Travell J.G. and Simmons D.G. Myofascial Pain and Dysfunction: Trigger Point Manuel. The Lower Extremities. Vol. (2) USA: Williams and Wilkins; pp248-327, 1983.

Travell J.G., Simons D.G. and Simons L.S. Myofascial Pain and Dysfunction: Trigger Point Manuel. Upper half of the body. Second Edition Vol 1. USA: Williams and Wilkins; Pp. 821–2, 829–30, 1999.

Van Der Heijden RA, Lankhorst NE, Van Linschoten R, Bierma-Zeinstra SM, Van Middelkoop M. Exercise for treating patellofemoral pain syndrome: an abridged version of Cochrane systematic review. Eur J Phys Rehabil Med. 52(1):110-33, 2016.