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Original Research Article

Effects of Ultrasound Therapy versus Mikhled Knee Exercise Program for Treating Patellofemoral Pain Syndrome

Mikhled F. Maayah,[1,2] Amr A. Abdel-aziem,[2*] Emad T. Ahmed[2]

[1]Department of Physiotherapy, Faculty of Applied Medical Sciences, Jordon University of Science and Technology.22110 Irbid PO Box 3030- Jordon
[2]Department of Physical Therapy, College of Applied Medical Sciences, Taif University, KSA

[*]Correspondence Email: amralmaz@yahoo.com

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ABSTRACT

Purpose: Patellofemoral pain syndrome (PFPS) is one of the most common problems in the knee joint. So, the purpose of this study was to evaluate the effects of ultrasound therapy versus Mikhled knee exercise program (MKEP) for treating patellofemoral pain syndrome. **Study design:** A randomized comparative single blind clinical study.Methods: A total of 60 subjects with confirmed patellofemoral pain syndrome (male and female) subject ≤20 years of age (MKEP, n = 20; Ultrasound, n = 20; MKEP + Ultrasound, n = 20) were recruited in the study. Ratings of pain was measured with a 10-mm visual analog scale (VAS), general health by using SF-36 and heath status by using WOMAC was obtained before and after the intervention. **Results:** ANOVA revealed that Mikhled knee exercise program combined with ultrasound produced significant decrease in pain level and significant improvement in function level ($p<0.05$). Conclusion: The findings of the current study of intervention program demonstrate that Mikhled knee exercise program combined with ultrasound therapy reduces pain and increases function in patient with PFPS.
Keywords: Patellofemoralsyndrome, Knee pain, Ultrasound, Isometric exercise.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most common knee joint problems in musculoskeletal disorders presenting to outpatient clinics. [1,2] Witvrouw et al. [3] stated that the incidence of patellofemoral pain in the general population is 25% in adolescents and adults. [3, 4] Patellofemoral pain syndrome can be defined as retropatellar or peripatellar pain, aggravated by climbing stairs, running, squatting, cycling and long sitting with flexed knees for prolonged periods of time. [5, 6] Patellofemoral pain is caused by patellar malalignment, quadriceps atrophy or patellofemoral maltracking and congruity. [7, 8]

PFPSfrequently becomes a chronic problem, forcing the patient to stop activities. [3] The long-term prognosis is generally more favorable for young patients, but seems to be independent of the presence of cartilage damage or gender. [9] Patients with PFPS might repeatedly visit physicians and physiotherapists to solve their problem. About 94% of these patients continue to experience pain up to 4 years after initial presentation and 25% state significant symptoms up to 20 years later. [10]

A wide variety of conservative treatment programs have been conducted. [3, 11] Although physical therapy forms the mainstay of nonsurgical management for patellofemoral pain, its efficacy has not been established. Clinically, intervention programs for patients with PFPS often include quadriceps strengthening exercise program (isometric exercise) to promote stabilization of the patella within the femoral trochea. [3, 10] Crossley et al. [12] reported a treatment plan composed of 6 sessions, once weekly, for patient with patellofemoral pain they received physical therapy regimen includes quadriceps muscle retraining, patellofemoral joint mobilization, patellar taping, and daily home exercises, another group received sham ultrasound. The study showed that6-week physical therapy regimen significantly reduces pain in the quadriceps program group, whereas, no significant improvement in the placebo group has been reported.

Heintjes et al. [13] identifies 3 trials therapy exercises with a control group, they found limited evidence that exercise has any benefit and recommendation further study to confirm this conclusion. In a recent study conducted by Fagan and Delahunt [14] some exercise programs have been shown to reduce pain and improve function in patient with PFPS. In contrast, several randomized controlled trials have reported positive results in pain and function using exercise-based interventions. [15-19]

Mikhled knee exercise program (MKEP) is a recently developed therapeutic technique to enhance joint health status, quality of life, range of motion, pain, balance, and muscular strength. The technique involves performing isometric movements of the hip, knee, and ankle from 7 therapeutic postures to strengthen the agonists and antagonists around the knee joint (i.e., quadriceps and hamstrings). However, no studies have examined the direct and residual effects of this technique on subjects with patellofemoral pain syndrome.

Ultrasound therapy has gained popularity as a well-accepted physical therapy modality for the management of musculoskeletal conditions. However, there is variation in the use of ultrasound between various countries, with physiotherapists in Canada and the United Kingdom and physical therapists in the United States of America using it approximately 1%, 50% and 94%, as a treatment modality, respectively. [20, 21]

Brosseau et al. [22] conducted study on patients suffering from PFPS and found that the ultrasound and ice massage group reported 46%improved pain relief compared to 31% in the ice massage alone group. This difference of 15% does not meet international standards for clinically important improvement in osteoarthritis of 20%. So, this study was conducted to evaluate the effects of ultrasound therapy versus Mikhled knee exercise program for treating patellofemoral pain syndrome.

MATERIALS AND METHODS

Subjects

Sixty patients who were referred to the physiotherapy department from specialist physicians with a confirmed diagnosis of PFPS participated in the study. The study included subjects aged 15 to 80 years old presented with diffused anterior knee pain for at least 8 weeks. They were exacerbated by climbing stairs, prolonged sitting, walking, running, squatting, knee flexion, and isometric quadriceps contraction. Patients had never received ultrasound and MKEP before. Subjects with any of the following disorders were excluded: tendonitis, Osgood-Schlatter syndrome, known articular cartilage, tendinopathy OA, previous knee surgery (including arthroscopy), fracture, history of patellar dislocation/subluxation, or meniscus or ligament damage or hypertension or heart diseases and a concussion within the last year or any neurologic deficit. Subjects were randomly assigned to the three groups the MKEP (n = 20), Ultrasound group (n = 20) and MKEP + Ultrasound therapy (n = 20) by using a random number generator.

Outcome Measures

Weekly pain

Subjects' pain was assessed using a 10-cm VAS. The extreme left side of the VAS stated "no pain" whereas the extreme right side stated "worse pain imaginable." Subjects drew a perpendicular line on the scale at the position that most likely described their usual pain over the previous week. [23]

The Western Ontario and McMaster Universities osteoarthritis index (WOMAC)

The WOMAC index has been designed to measure dysfunction and pain associated with OA of the lower extremities. It consists of 24 items: five to assess pain, two to assess stiffness and 17 to assess physical function; it takes five minutes to complete. Each of the sections is scored individually for the three dimensions of pain, stiffness and physical function by summing the coded responses and the scores range of 0 – 4. A low score indicates good health. [24] There are five alternative answers to every question (0 = none, 1 = mild, 2 = moderate, 3 = severe, 4 = extreme). The maximum score in LK scale is 20 points for pain, 8 points for stiffness, and 68 points for physical function. Higher scores indicate more or worse symptoms, maximal limitations, and poor health.

Quality of Life (SF-36)

The SF-36 is a self-administrated questionnaire containing 36 items. It takes between 5 and 10 minutes to complete. [25, 26] The scores are based on responses to individual questions and are summarized into eight scales, each of which measures a health concept. [27, 28] It includes eight subscales measuring physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. All items pertaining to each scale are summed and transformed to form a scale from 0 to 100. A higher score indicates a better state of health or well-being. [29, 30] All items pertaining to each scale (excluding health transition) are summed and transformed to form a scale from 0 to 100, where a higher score indicates a better state of health or well-being. Subjects are assessed for pain intensity using the 10cm Visual Analogue Scale (VAS).

Procedures

Subjects with PFPS were recruited through a referral to the physiotherapy department at King Abdullah University Hospital from specialist physicians. Subjects of either sex fulfilling the required criteria and agreed to take part in the study as indicated by signing a consent form. On agreeing to participate in the study, the 60 subjects attended the physiotherapy department were interview by the investigator to ensure that they met the inclusion and exclusion criteria. Each subject also recorded other factors, such as the sex, age, and pain severity. The participants were randomly assigned to 1 of 3 groups: Group (A) received MKEP; Group (B) received MKEP combined with ultrasound therapy and Group (C) receivedultrasound therapy. Training program consisted of 3 to 8 weekly sessions. Subjects were treated with either MKEP (n

=20) for 30 minute or Ultrasound therapy (n=20) for 5 minutes or MKEP combined with therapeutic (n=20).

The MKEP involves a series of active gentle movements and postures aimed position to allow for more contraction and enhancing the contraction of antagonist muscles, thus avoiding postural internal or external rotations. These therapeutic postures imply an active involvement of the patient. The MKEP method includes seven therapeutic level postures, Level 1: supine; Level 2: on elbows; Level 3: half sitting; Level 4: prone; Level 5: bench long sitting; Level 6: bench prone; Level 7: bench supine, to be held for 15/20 minutes each. Each level contain the same exercise but in different as the following: 1) The patient was instructed to straighten the knee joint and take the toes of the foot towards your body (Dorsiflexion); 2) The patient was instructed to left his/her leg up for 15 inches while keeping the knee straight; 3) The patient was instructed to take his/her leg outside the body in abduction position while keeping the knee in the straight position; 4) The patient was instructed to bend (flex) his/her knee for 30° while keeping the knee outside the body; 5) The patient was instructed to extend his/her knee while keeping legs in neutral position; 6) The patient was instructed to take his leg inside position like second steps and then ask the patient to back to the first step and relax for 30 seconds. After each therapeutic level of isometric exercise ask the patient to hold for 10 seconds or count for 10. The postures used are considered the most effective in strengthening the quadriceps muscles and hamstring muscles, which is usually weak or atrophy in patients with OA.This study approved by ethical committee of Jordan University of Science and Technology.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 16). Analysis of variance (ANOVA) was used to evaluate the effects of ultrasound therapy versus Mikhled knee exercise program for treating PFPS. The level of significant was set at 0.05 for all statistical tests.

RESULT

Analysis of variance revealed no statistically significant differences between the groups in terms of age, weekly pain, WOMAC and SF-36 before the interventions program (p›0.05).

1. Visual Analogue Scale (VAS)

The statistical analysis of visual analogue scale values revealed that the three methods of treatment produced a significant improvement in the three groups, for group A (P= 0.019), for group B and C (P= 0.000). There was no significant difference between the pre values of the three groups (P> 0.05); the improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.000, 0.001; respectively Table 1).

2. Western Ontario and McMaster universities Osteoarthritis Index (WOMAC)

For WOMAC pain values the results proved that the three methods of treatment produced a significant reduction in pain level in the three groups, for group A and B (P= 0.000), for group C (P= 0.001). There was no significant difference between the pre values of the three groups (P> 0.05); the improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.015, 0.023; respectively Table 1).

For WOMAC stiffness values the results proved that the three methods of treatment produced a significant reduction in joint stiffness for the three groups, for group A (P= 0.012), group B (P= 0.001), and group C (P= 0.032). There was no significant difference between the pre values of the three groups (P> 0.05); there was no significant difference between three methods of treatment in the joint stiffness reduction (P > 0.05).

Table 1: Pre and post values of VAS, WOMAC (pain, stiffness and physical) variables.

Variables	Group A (n = 20) (Mean ± SD)		Group B (n = 20) (Mean ± SD)		Group C (n = 20) (Mean ± SD)	
	Pre	Post	Pre	Post	Pre	Post
VAS	5.10±1.48	3.17±1.80	5.58±2.37	1.95±1.39	6.23±1.64	3.45±2.63
Pain	13.60±3.62	9.65±2.28	13.65±3.25	7.25±1.89	12.95±3.36	9.50±3.63
stiffness	1.50±1.73	0.50±0.76	1.45±1.47	0.10±0.31	1.40±1.6	0.55±0.89
physical	40.60±9.34	28.55±10.98	43.75±8.43	22.0±4.90	43.3±10.96	32.15±12.70

For WOMAC physical function values the results proved that the three methods of treatment produced a significant improvement in physical level in the three groups, for group A and B (P= 0.000), for group C (P= 0.001). There was no significant difference between the pre values of the three groups (P> 0.05); the improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.038, 0.002; respectively), as shown in Table 1.

3. Short-Form (SF-36)

For general health (GH) values the results proved that the three methods of treatment produced a significant improvement in the three groups, for group A and group B (P= 0.000), and group C (P= 0.002). There was no significant difference between the pre values of the three groups (P> 0.05). The improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.001, 0.010; respectively).

For physical function (PF) values the results proved that the three methods of treatment produced a significant improvement in the three groups (P= 0.000). There was no significant difference between the pre values of the three groups (P> 0.05). The improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.019, 0.012; respectively), as shown in Table 2.

For role physical (RP) values the results proved that the three methods of treatment produced a significant improvement in the three groups (P= 0.000). There was no significant difference between the pre values of the three groups (P> 0.05). The improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.000).

For role emotional (RE) values the results proved that the three methods of treatment produced a significant improvement in the three groups (P= 0.000). There was no significant difference between the pre values of the three groups (P> 0.05). The improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.001), as shown in Table 2.

For social functioning (SF) values the results proved that the three methods of treatment produced a significant improvement in SF of the three groups, for group A (P= 0.028), group B (P= 0.010), and group C (P= 0.046). There was no significant difference between the pre values of the three groups (P> 0.05). There was no significant difference between three methods of treatment for the level of improvement of SF (P > 0.05).

For bodily pain (BP) values the results proved that the three methods of treatment produced a significant improvement in the level of BP for the three groups, for group A (P= 0.005), group B (P=

0.001), and group C (P= 0.025). There was no significant difference between the pre values of the three groups (P> 0.05). There was no significant difference between three methods of treatment for the level of improvement of bodily pain (P > 0.05), as shown in Table 2.

For mental health (MH) values the results proved that the three methods of treatment produced a significant improvement in the MH level for the three groups, for group A (P= 0.005), group B (P= 0.034), and group C (P= 0.023). There was no significant difference between the pre values of the three groups (P> 0.05). There was no significant difference between three methods of treatment for the level of improvement of mental health level (P > 0.05) as shown in Table 2.

For vitality (V) values the results proved that the three methods of treatment produced a significant improvement in the three groups, for group A (P= 0.002), for group B and C (P= 0.000). There was no significant difference between the pre values of the three groups (P> 0.05). The improvement of group (B) was significantly higher than group (A) and group (C) (P= 0.002, 0.015; respectively), as shown in Table 2.

Table 2. Pre and post values of SF-36 (GH, PF, RP, RE, SF, BP, MH & V) variables.

Variables	Group A, n=20 (Mean ± SD)		Group B, n=20 (Mean ± SD)		Group C, n=20 (Mean ± SD)	
	Pre	Post	Pre	Post	Pre	Post
GH	19.30±2.90	16.55±2.64	19.7±1.63	14.1±1.74	18.45±2.01	16.05±2.74
PF	22.05±2.46	15.95±4.63	20.65±2.56	13.45±2.5	21.65±2.72	16.15±4.37
RP	8.2±0.52	10.45±1.50	8.05±0.22	11.7±1.08	8.6±1.23	10.35±1.84
RE	4.3±1.49	7.3±1.42	4.8±2.14	8.8±1.54	4.4±1.16	6.7±2.53
SF	3.05±0.94	2.5±0.69	3.1±0.45	2.45±0.69	2.85±0.93	2.35±0.88
BP	6.05±1.50	4.85±0.88	5.85±1.84	4.35±1.35	5.80±1.11	4.85±1.04
MH	26.40±4.15	29.05±1.82	26.65±2.25	28.65±3.31	27.8±3.44	29.95±1.93
V	3.05±0.94	2.3±0.89	3.50±0.89	1.55±0.60	3.5±0.76	2.15±0.67

GH: General Health; PF: Physical Function; RP: Role Physical; RE: Role Emotional; SF: Social Functioning; BP: Bodily Pain; MH: Mental Health; V: Vitality

DISCUSSION

This study was conducted to evaluate the effect of the application of ultrasound therapy and MKEP on pain, health status and quality of life in patient with PFPs. The results of the study indicated that no significant difference between group (A) and (C). Whereas, the ultrasound therapy combined with MKEP (Group B) significantly reduced the pain, improved the physical activities and improved general health at the end of the 6 weeks interventions program.

The current study is the first randomized trial study that tests the effectiveness of MKEP versus ultrasound therapy program in patient with PFPS. The results of the current study demonstrate the effectiveness of both interventions in increasing physical function levels and pain reduction in patient during the intervention period. Therefore, the improvement of MKEP combined with ultrasound therapy has proven significantly higher than MKEP and ultrasound therapy alone.

Mikhled knee exercise program is a conventional treatment program for patient with PFPS. Isometric quadriceps exercises are mainly preferred in the treatment of patient with PFPS. In the present study, the participants have been instructed to use a home exercise program, consisting of MKEP. The findings of the current study show that the MKEP can be effective in pain, health status and quality of life when used alone, or in combination with ultrasound therapy.

Mikhled knee exercise is a form of knee isometric exercises that have some differences in training effect as compared to dynamic exercises. Isometric training exercises increase the muscle strength at the specific joint angles performed by exercises and additional joint angles to a lesser extent. Dynamic training exercises increase the muscle strength throughout the full range of motion. [31] Isometric exercises can be used for general strength conditioning and for rehabilitation where strengthening the muscles without producing any changes in the joint range of motion. Whereas, the dynamic training exercise increases muscle strength with producing full range of motion.

Dynamic exercises are slightly better than isometric exercises at enhancing the twitch force of a muscle immediately after completion of the dynamic training exercise. In contrast, isometric exercises are significantly better than dynamic exercises at increasing maximal strength at the joint angle. [32] Flexibility may be increased when isometrics are performed at joint range of motion extremes. These isometric contractions recruit muscle fibers that are often neglected in some dynamic exercises. So that, MKEP does not require equipment, it might be found more convenient to continue doing the exercises at home by themselves. For example, gymnasts are extremely strong at great ranges of motion through the practice of isometric holds.
Crossley et al. [12] have shown that 6-week physical therapy regimen significantly reduces pain in the quadriceps program group. No significant improvement in the placebo group has been found. The findings of these studies support the present study with respect to pain reduction and reduced disability in patient with PFPS.

Michener et al. [33] and Gürsel et al. [34] have reported no significant differences between true ultrasound therapy and sham ultrasound therapy for subjects with soft-tissue disorders of the shoulder joint. Whereas, the current study showed significant improvementof patient with PFPS treated by ultrasound combined by with exercise rather than other groups were treated by ultrasound or exercise alone. Conversely, several studies have supported the efficacy of ultrasound therapy in reducing pain, improving activities of daily living, and improving quality of life. [35, 36] In particular, Ebenbichler et al. [36] reported that 24 daily applications of ultrasound therapy at 2.5 W/cm2 (5 times per week for 3 weeks and then 3 times per week for 3 weeks) reduced the painful symptoms in patients with calcific tendinitis of the supraspinatus tendon.

Brosseau, et al. [22] stated that the ultrasoundtherapy was not shown to have a clinically important effect on pain relief for patients with PFPS. These conclusions are limited by the poor reporting of the therapeutic application of the ultrasound and low methodological quality of the trial included. No conclusions can be drawn concerning the use or non use of ultrasound therapy for treating PFPS. More well-designed studies are needed. On the contrary the present study demonstrated significant improvements in pain and disability of both groups with PFPS.

The exact mechanism of action of ultrasound remains unknown although it is used to treat various musculoskeletal disorders. Analgesic effect induced by therapeutic ultrasound may be the result of increased capillaries permeability and tissue metabolism, enhancement of fibrous tissue extensibility and elevation of pain threshold by thermal mechanisms. [37, 38, 39] deep heating with ultrasound can produce a temporary increase in extensibility of highly collagenous structures such as tendons, ligaments and joints capsules.[38, 40] Non-thermal effects are less well understood and include molecular vibration, which increases cell membrane permeability and thereby enhances metabolic product transport, fibroblast production, collagen synthesis, and alterations to extracellular matrix arrangement.[37, 38] It is thought that pain relief may occur as a result of activation Aα and Aβ mechanoreceptors that inhibits nociceptive transmission Aδ and C-fiber pathways as a proposed pain-gating mechanism.[41]

The results of GH, PF, RE, RP and V of the present study showed that the improvement of MKEP combined with ultrasound therapy is significantly higher than MKEP group and ultrasound therapy alone groups. Whereas, there is no significant difference between three methods of intervention for the level improvement of the bodily pain, social functioning and mental health. Similarly, the results of the WOMAC (pain and physical function) showed that the improvement of MKEP combined with ultrasound therapy was significantly higher than MKEP group and ultrasound therapy group alone. Whereas, there was no significant difference between the three methods of intervention for the level improvement of the stiffness. The findings of the present study proved that the ultrasoundtherapy combined with MKEP has a clinically important effect on pain relief, increasing physical function and reduction of disability for patients with PFPS. However, the combination of ultrasound therapy and Mikhled knee exercise leads to gaining higher improvement.

There are some limitations of this study that need to be considered. Firstly; the small number of participants in each group has affected the power of the study. Secondly; changes in other environmental factors such as lifestyle, diet, activity level could not be controlled. However, records of physical activities, weight, height, disease duration and medication were taken to document any difference between groups.

CONCLUSION

The current study proved that MKEP can be effective when used alone or in combinations with ultrasound therapy in reducing pain and increasing physical function in patient with PFPS. This finding provides clinicians with new outcome measures in order to devise the effect of the new exercise program as a treatment of patient with patellofemoral pain syndrome.

Disclosure

The authors report no conflicts of interest in the work of the current study.

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