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Research Article

Effects of Total Resistance Exercise versus Physioball Exercise Training Programs on Pain and Functional Disability among Women with Patellofemoral Pain

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Abstract

Background: patellofemoral pain syndrome (PFPS) is one of the most common knee injuries, which is caused by the abnormal position of patella. The present study was conducted to compare the effects of an eight-week training in both Total Resistance exercise (TRX) and physioball groups on the amount of pain and motor function of non-athletic women with patellofemoral pain syndrome.
Methods: In this semi-experimental study, 30 non-athletic women suffering from patellofemoral pain syndrome were randomly divided into two groups. The first group performed TRX exercises (15 people), and the second group performed physioball exercises (15 people). Both groups received 3 practice sessions per week for a period of 8 weeks. The visual analog scale (VAS), pain scale and *Kujala* Patellofemoral *questionnaire* (KPQ) were employed before and after the exercise to assess the pain and motor function. Paired T-test and independent t-test were used. The significance level was considered as $P \leq 0.05$.
Results: The results revealed that there was no significant difference between functional disability (P=0.14) before and after the exercise protocol (pre- and post-test) in the physioball group. Meanwhile, there was a significant difference in pain (P=0.028). The results for the TRX group indicated that there was a significant difference in pain (P=0.001) and functional disability (P=0.001) between pre- and post-test exercises.
Conclusion: The findings of our study revealed that the eight weeks of the strength training program (TRX and physioball) might be beneficial in a conservative treatment plan for reducing the pain intensity and improving the functional disability for subjects with PFPS.

Keywords: Patellofemoral pain syndrome, Knee, Exercise, Visual Analog Scale

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1. Introduction

Patellofemoral pain syndrome (PFPS) is known to be one of the most prevalent knee disorders that 25% of people experience during their lifetime, which is more common among women than men (1, 2). This disorder is seen in the morning and after waking up, and decreases with the onset of movement and reappears after the onset of activity (3). The risk factors of this syndrome include quadriceps muscle weakness, patellar displacement, loosening of ligaments, and stiffness of the external retinaculum, muscle imbalance and weakness in the proximal and distal limbs, overuse syndromes, weakness of the lower limb ligaments such as increased Q angle, poor foot biomechanics, excessive foot pronation in which the foot rotates inward, increase in knee valgus, high body mass index, the abnormal displacement of the patella to the femur. The cause of this displacement has been suggested to be a delay in the onset of activity of the Vastus medialis muscle related to the Vastus lateralis muscle (4, 5). The primary step in treating patellofemoral pain syndrome is a conservative treatment involving non-surgical interventions, such as rest, ice, anti-inflammatory drugs, activity regulation, and physiotherapy. Physiotherapy includes specific knee exercises, for instance quadriceps muscle strengthening exercises. Studies have shown that with quadriceps muscle exercises people could manage their pain (6). Stretching exercises, such as iliotibial band stretch, tensor fasciae latae muscle, and hamstrings improve pain (7). Other treatments include patella taping, foot orthosis, electrotherapy, and biofeedback can be used (8). Other exercises include strengthening the hip area. Studies have reported significant improvements in pain in people who had hip flexor and extensor muscles strengthening in their treatment programs (9, 10). In this regards, the physical therapists or clinicians use self-reported assessment of pain and function to check the effectiveness of various physical therapy interventions. The Visual Analog Scale (VAS) is the most common tool utilized to measure pain intensity, which is believed to be a valid and reliable measure (3, 11).

Core stabilization is of great importance in exercise. That is owing to the fact that it provides stability to the upper parts of the body to perform movements in the lower parts of the body. These muscles' strength allows the system to stabilize the spine mechanically and then distribute and deliver translational, compressive, and shear forces to and from the rest of the body (12). People with patellofemoral syndrome are believed to be suffering from core muscle weakness (12, 13), and the effects of core muscle strengthening have been proven as an effective method of management in various cases (14, 15). Previous studies have shown that most knee injuries are caused by core *instability* due to decreased hip strength (16)tibia, femur, and hip. Research evidence supports the presence of a dynamic coupling mechanism between lower limb segments, however, the direction of the coupling is inconclusive.Recent prospective investigations of the role of the lumbo-pelvic hip complex have identified a strong association between proximal dysfunction and increased risk of lower limb injuries. Strength of muscles of the lumbo-pelvic hip complex (core muscles. Therefore, strengthening exercises in the core area reduce pain and improve dynamic balance in people with patellofemoral pain syndrome (17)which can result from core muscles instability that can lead to pain and altered dynamic balance. The objective of this study is to assess the effect of core muscle strengthening on pain and dynamic balance in female patients with patellofemoral pain syndrome. [Subjects and Methods] Twenty female patients with age ranging from 16 to 40 years with patellofemoral pain syndrome were divided into study (N=10).

In particular, in order to have a fit body and increase the strength and endurance of the trunk muscles, TRX exercises for the trunk muscles and lower limb muscles are highly recommended (18). In general, studies suggest that *suspension* training exercises increase muscle activity in the trunk area (19). Jean Teh and other colleagues (2013) reported that TRX exercises augment core muscle activity during plank exercises (20). Gaedtke and other colleagues (2014) demonstrated that TRX training in the elderly could be effective in improving muscle strength and performance (21)a form of functional training, was primarily developed for therapy and rehabilitation. Due to its effects (core muscle activation, strength and balance improvements. Even though the evidence suggests that adding core exercises to the exercises of people with this disorder improves the pain and their function, no research has been found that examines the effects of strengthening exercises of the core with TRX exercise. Therefore, the objective of this study is to define the effects of TRX and physioball exercises on pain and functional disability among women with PFPS.

2. Methods

The research method is semi-experimental with pre-test and post-test design. The statistical sample included 30 women aged between 25 to 40 years old in Savojbolagh city who suffered from patellofemoral pain. According to G. power software (G*Power, Franz Faul University of Kiel, Germany, version 3.1.9.2.) with an alpha type I error of 0.05 and a beta type II error of 0.2 , based on the results of Mattia Uboldi and other colleagues (22) and taking into consideration the difference between the mean and standard deviation of the VAS between the control (3.0±1.5) and the experimental (1.4±1.6) groups, 15 subjects were required in this study in each group. Accordingly, using sequences of random numbers, the subjects were randomly divided into two groups of those exercising with TRX (15 participants) and those exercising with physioball (15 participants) (Table 1). After classifying the subjects, they completed the *Kujala* Patellofemoral *questionnaire* (KPQ) and the VAS, and each group performed a special exercise protocol. In this section,

Table 3: Demographic characteristics of the subjects in TRX and Physioball groups (Mean ± SD)

Variable	Group (TRX=15, physioball=15)	mean±standard deviation (Mean±SD)	P value
Age (year)	TRX	33.13±2.19	2.78
	physioball	32.20±2.24	
Height (cm)	TRX	160.73±4.14	0.18
	physioball	161.20±3.46	
Weight (kg)	TRX	62.93±7.14	0.23
	physioball	60.60±4.15	
BMI	TRX	22.30±2.35	0.41
	physioball	22.17±3.25	

TRX: Total Resistance exercises; *Significant level P<0.05

people with patellofemoral pain syndrome were selected based on the following inclusion criteria: pain in the back of the patella or anterior knee that is exacerbated during activities, such as sitting for long periods of time, running and limping, going up and down the stairs, and kneeling; feeling pain when touching the patellar fascia; feeling pain after performing a Clark clinical test. The exclusion criteria included structural abnormalities in the lower limbs, history of fractures in the knee joint, knee surgery, limited mobility of the knee joint, and dislocation or *partial*-dislocation of the patella (23). Ethical approval was obtained from the ethical committee of the medical faculty of the Allameh Tabataba'i University ethic review board (Ethics code number: S/9/18/45372).

Procedures: In the present work, the exercises were performed for eight weeks, three sessions a week on even days. The time dedicated to ne training session was about 60 minutes. Initially, the subjects performed the warm-up and stretching exercises for 10-15 minutes before starting the main protocol to prevent possible injuries to the neuromuscular system. Subsequently, about 35-40 minutes were spent to perform the main protocol of exercises and it took about 5-10 minutes to cool down. Each exercise was performed in 2 sets and 10 repetitions in the initial sessions and in the next sessions with further progress, in 3 sets with 12 repetitions (Tables 2 and 3). There was a two-minute break between each set and each movement. It is noteworthy to mention that in this study, there was mutual trust and confidence between the patients and the therapist. Following the training period (8 weeks), the re-evaluation was done.

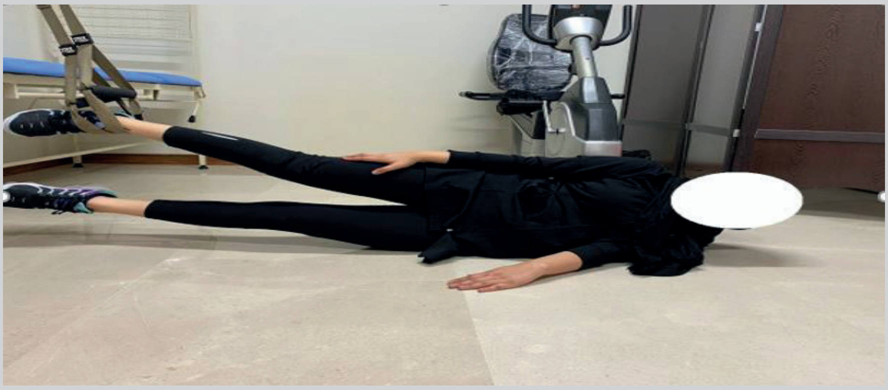
The outcome measures employed in the current reaserch were: VAS and KPQ measurement. Both these measures were assessed at the start of the study and at the end of the 8 weeks of intervention.

KPQ measurement: This questionnaire aimed to assess individual performance and patellofemoral pain during specific activities. Herein, the maximum score was 100. Higher scores denote higher levels of

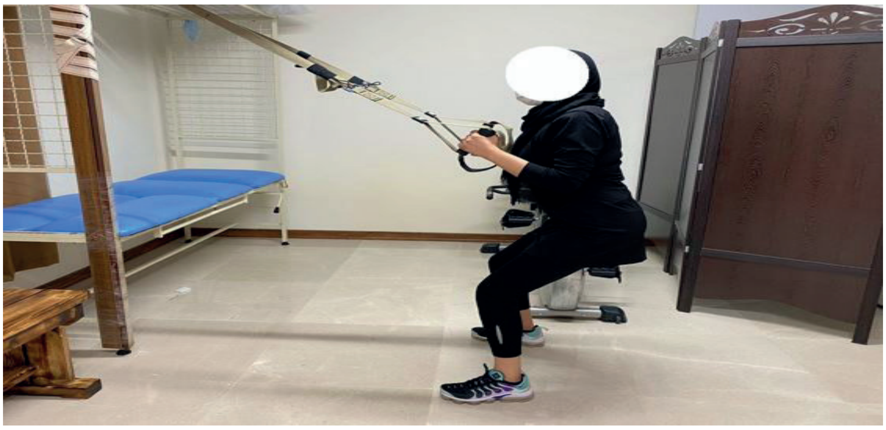
Table 1: TRX exercise protocol

1. The person is lying on the floor in a supine position and while the knee is inside the TRX handle, the ankle and leg are taken to flexion and extension up to 60 degrees.	
2. The person is in the above position and this time the ankle is inside the handles and while the knee is 60 degrees bent, she tries to bring the back of the knee closer to the ground.	

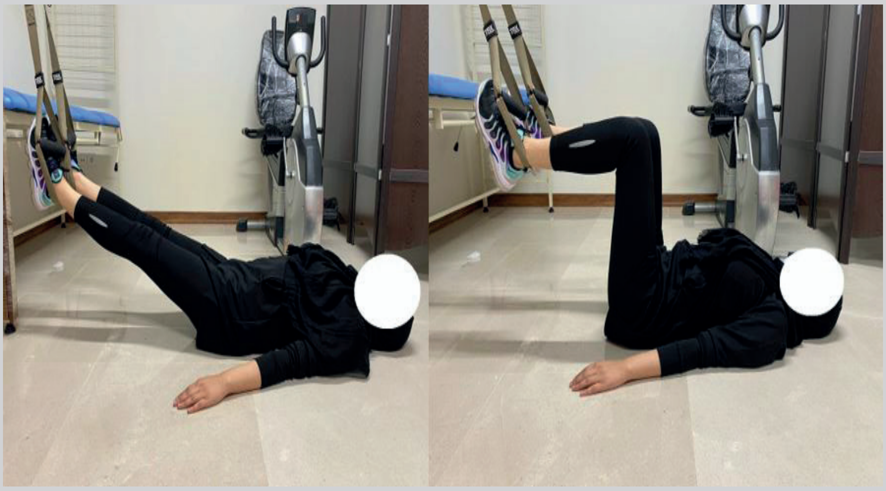
3. The person is lying on her side on the floor and the ankle of one foot is in the handle and the person is trying to abduct the foot.



4. In this exercise, while the subject is taking hold of the handle, she tries to perform Squat at 40 degrees.

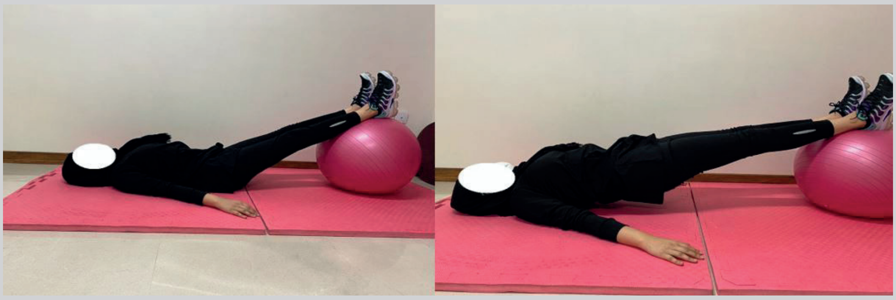
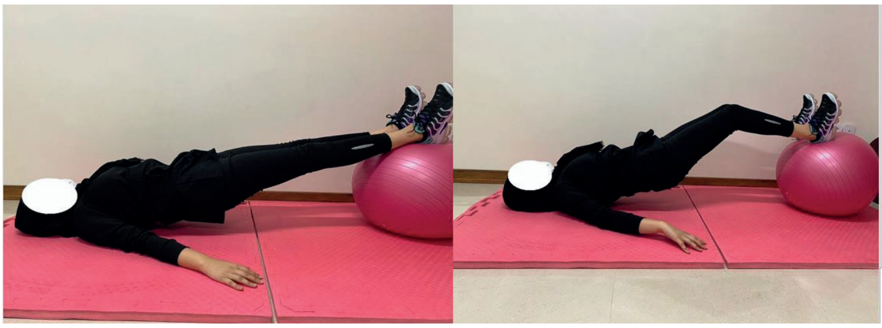
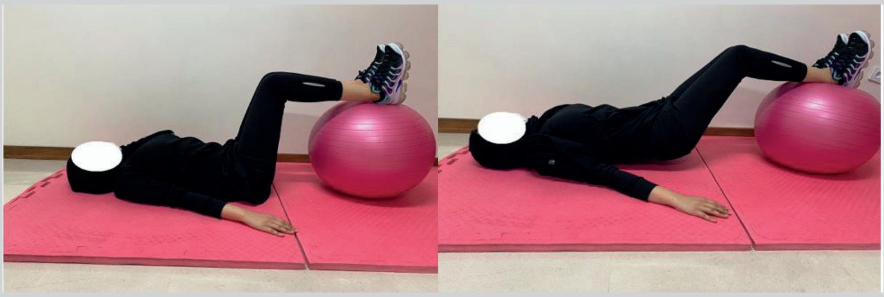
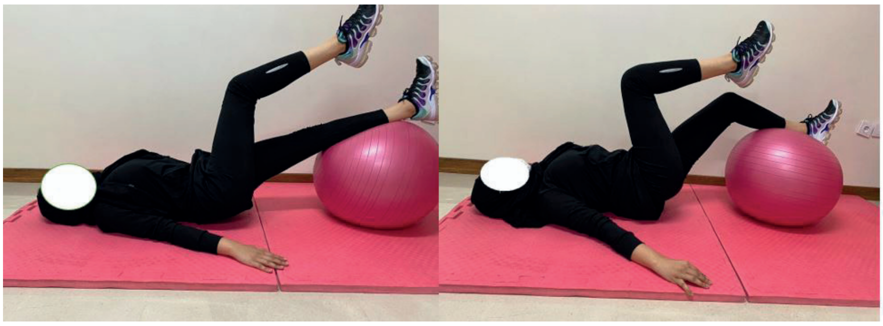
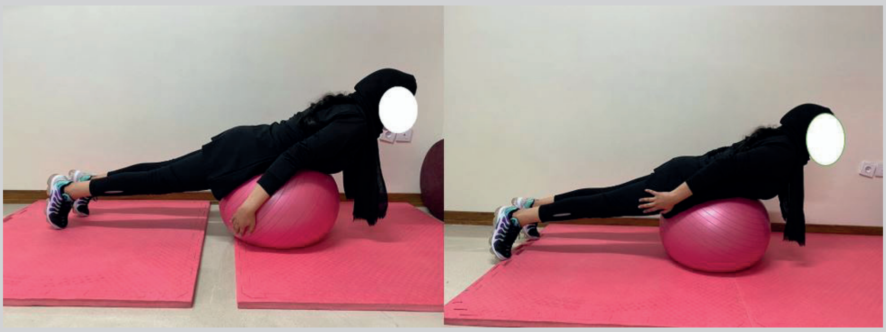


5. In this exercise, the person is lying on the ground, the ankles are inside the handles and the person is trying to do leg flexion and extension.



6. In this exercise, while the person is taking hold of the handle, she performs the exercise in a launch position.

Table 2: Physioball exercise protocol

1. The subject lies in supine position on the floor with the ball under both ankles, and the person tries to lift the buttocks and legs off the ground while the neck and spine are on the floor.	
2. The subject is in the above position and bends the knees while raising the body.	
3. In this exercise, the person's ankles are placed on the ball with a bent knee and the person tries to lift the body.	
4. In this exercise, the ankle of one foot is on the ball and the person bends the knee on the ball while lifting the body.	
5. The person is on the ball with her stomach and the sole of the foot leaning against the wall, and she starts to bend the knees and contract the gluteal muscles.	

performance and lower scores imply lower levels of performance. This questionnaire contains 13 items whose calculated validity is 96% (24). Moreover, it is reported that the Persian version of KPS is a reliable and valid outcome measure of disability and seems to be a suitable instrument for clinical practice of Iranian patients with PFPS (25). It was implemented as follows: before the beginning of the rehabilitation course, it was completed by each of the subjects and its containing information contained was recorded. The subjects completed the questionnaire at the end of the rehabilitation period again after 8 weeks of exercises and thus, the effects of the training protocol were presented after the rehabilitation period.

VAS measurement: This scale was used to assess the severity of the pain experienced in the patellofemoral joint. This demonstrates the pain intensity on a 10-point scale, in which zero denotes no pain and 10 represents unbearable pain and inability to walk (26)accurate and reliable measures of this condition are required. This study investigated the test retest reliability and inter-relationship of five self-report questionnaire indices used in PFPS to measure functional limitation or severity of pain, in general or during specific aggravating activities for PFPS. Design: A repeated measures and correlational design. Participants: Fifty subjects (17 male, 33 female. Before the completion of the relevant questionnaire by the subjects, the VAS scale was fully and clearly explained by the researcher, so that the subjects have a clear understanding of how to complete the questionnaire and apply their pain to the questionnaire correctly. This test has high reliability and validity.

Statistical Analysis

Descriptive analysis (mean and standard deviation) was performed on all the variables. The Shapiro–Wilk test was used to ascertain whether the data showed normal distribution.

Therefore, to compare the mean of within-group differences (pre- and post-test data), paired T-Test was used, and the Independent T-Test was utilized for between-group comparisons. Statistical significance set a priori at $\alpha<0.05$. The Statistical Package for the Social Sciences (SPSS version 18.0, Microsoft Corp., Redmond, WA) was used for all the statistical analyses.

3. Results

No significant differences were found regarding age, height, weight, or BMI between the groups (Table 1). The results showed that there was no significant difference between the functional disability (P=0.14) before and after the exercise protocol (pre- and post-test) in the physioball group, yet there was a significant difference in the pain (P=0.028). On the other hand, the results for the TRX group indicated a significant difference in the pain (P=0.001) and the functional disability (P=0.001) between pre- and post-test exercises (Table 4). Furthermore, the results based on an independent t-test implied that there was a significant difference in the pain (P=0.001) and the functional disability (P=0.001) between the two groups (Table 4).

4. Discussion

The findings of the present study demonstrated that exercise in the TRX group was significantly effective, and this effect eventually led to a reduction in the pain in subjects with PFPS. Ultimately, according to our results (Table 4), it can be stated that both training approaches significantly reduced the amount of pain, but the ability of the subjects in the TRX group to reduce the pain was proved to be better than that of the physioball group. Exercise in the TRX group in the pre-test and post-test stages significantly affected the improving performance, and these effects ultimately led to an increase and improvement in the motor function of individuals in each group. TRX had a greater impact on improving motor function compared to physioball exercise. The results of Sobhani and Mazloom's (2016) study showed that the patients with PFPS have weaker core muscles compared to healthy individuals (27). Probably because

Table 4: The effect of physioball and TRX exercises on pain and functional disability (Mean±SD)

Variable	Group	pre-test	post-test	Paired T-Test
VAS (cm)	physioball	4.31±1.67	4.08±1.61	0.028*
	TRX	4.30±1.48	3.18±0.96	0.001*
Independent T-Test		0.560	0.001*	
Functional disability (Score)	physioball	73.53±7.81	75.33±8.79	0.140
	TRX	76.31±3.81	83.73±5.09	0.001*
Independent T-Test		0.241	0.001*	

VAS: visual analog scale; *Significant level P<0.05

the core muscles include the diaphragm, pelvic floor, hip, multifidus, and abdominal muscles, stability of this area is the product of motor control and muscular capacity of the lumbopelvic-hip joint. The positive effects of strengthening exercises of hip abduction and external rotation muscles have been observed in improving the pain and function of patients with PFPS, which is consistent with the results of the present study (27). Chevidikunnan et al. (2016) reported that strength training in the core area reduced pain and improved PFPS more than other groups since strengthening the core muscles changes sensory or motor pathways (or both) in the muscles. It results into better stability in the proximal limbs and improves the PFPS (17)which can result from core muscles instability that can lead to pain and altered dynamic balance. The objective of this study is to assess the effect of core muscle strengthening on pain and dynamic balance in female patients with patellofemoral pain syndrome. [Subjects and Methods] Twenty female patients with age ranging from 16 to 40 years with patellofemoral pain syndrome were divided into study (N=10, which is in accordance with our results. Rojhani Shirazi and other colleagues (2014) suggested that improving the core muscles reduces pain and improves the function of the patients with patellofemoral pain syndrome (14). Having a sufficient proximal stability would reduce the stress load over the patellofemoral joint, which could be another evidence on the significance of pain reduction in the study group (17)which can result from core muscles instability that can lead to pain and altered dynamic balance. The objective of this study is to assess the effect of core muscle strengthening on pain and dynamic balance in female patients with patellofemoral pain syndrome. [Subjects and Methods] Twenty female patients with age ranging from 16 to 40 years with patellofemoral pain syndrome were divided into study (N=10. In a study by Hoch AZ, a significant improvement in terms of pain and function was reported in women with PFPS who received a proximal strengthening program, which is in agreement with our findings regarding the improvement in pain (28). Rostamizalani et al. (2018) examined the effect of strengthening core stability and quadriceps muscle strengthening trainings on pain and function in the patients with PFPS. Following the exercises, the two groups showed a reduction in pain and improved performance, as strengthening the muscles of core stability resulted in better pelvic control and preventing excessive proximity and internal hip rotation. That is owing to the fact that the muscles of the core stability of the trunk actually provide proximal stability for distal movement. Therefore, strengthening core stability of the trunk with its control role on the trunk improves the movement in the lower limbs and also the efficiency of the hip joint (29). Dudgeon et al. (2015) examined the physiological and metabolic effects of suspension training. Their results shed light to the fact that suspension training increases heart rate and subsequently, the blood circulation in the muscles, resulting in muscle building. In addition, suspension training can be a practical way to lose weight and increase the body's physical fitness (30). Mok and other colleagues (2014) also reported the core muscle activity during suspension exercises. The results demonstrated that the activity of the abdominal muscles during TRX exercises is higher than that with Swiss ball and step since this type of exercises includes movements that are against gravity, multi-dimensional and multi-joint, where the body weight is used as resistance and increases the core muscle activity (31). Byrne et al. (2014) studied the effect of using a suspension training system on muscle activation during the performance of a front plank exercise. TRX exercises were found to be an effective tool for increasing muscle activity during the exercise, and that unstable exercise increases muscle activity. Suspension training has become increasingly popular as an educational tool. Despite this popularity, there is relatively little research on the effects of such training on muscle activation (20). Marshall and Murphy (2006) suggested increased muscle activity once the core-strengthening exercises were performed on an unstable surface utilizing a Swiss Ball (32). Skindiz and other colleagues (2010) investigated the effects of strength training of the core muscles using the Swiss Ball on the strength, performance, flexibility and balance in pregnant women. The results showed that training with the core muscles with the help of Swiss ball could improve the above-mentioned cases. The suspension exercises should be taken advantage of as a tool to increase muscle strength (33). Certain limitation in our study included the relatively small sample size, although appropriate statistical power was obtained. Studies with larger number of subjects are required. The current research was conducted only on the female population, as it was clear from the literature that PFPS is more common among the female subjects compared to their male counterparts (34). However, the results of this study could be considered as a mode of treatment, even in the male population.

5. Conclusion

In conclusion, the results of the present study revealed that the eight weeks of the strength training program (TRX and physioball) might be beneficial in a conservative treatment plan in order to reduce the pain intensity and improve the functional disability in subjects suffering from PFPS.

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Ethical Approval: The Ethics Review Board of Allamah Tabataba'i University approved the present study with the following number: S/9/18/45372.

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Conflicts of interest: None to declare.

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