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Knee Alignment-Oriented Balance Exercises Versus Conventional Balance Exercises in Treating Patellofemoral Pain Syndrome

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ABSTRACT

Background*:* Patellofemoral pain syndrome (PFPS) is the most prevalent musculoskeletal disorder encountered by orthopedic physical therapists and one of the primary reasons for pain in the anterior part of the knee. Balance and Function of the knee may be affected in patients with PFPS due to pain and abnormal lower limb alignment.

Aim: to investigate and compare the effects of knee-alignment-oriented balance exercises and conventional balance exercises in patellofemoral pain syndrome patients with dynamic knee valgus.

Patients and Methods: Thirty-four patients were diagnosed with PFPS with dynamic knee valgus and were divided into group A: received knee alignment-oriented balance exercises while the other group B received conventional balance exercises. Dynamic knee-valgus throughout a Single-Legged Drop Jump test was measured via two-dimensional video analysis with the Kinovea software. Pain severity was assessed via a visual analog scale. Proprioception was assessed via dynamic postural stability with the Biodex Stability System (Biodex balance system).

Results: there was no statistically substantial difference among both groups concerning VAS as well as dynamic postural stability with (p-value>0.05) but for each group, there was a substantial decline in VAS (p=0.0001), as well as for dynamic posture stability, there was no substantial difference except the significant decrease in Anterior/Posterior Index (p=0.014) of the knee alignment-oriented balance group.

Conclusion: There was no significant difference between the knee alignment-oriented balance group and the conventional balance group regarding pain intensity and dynamic postural stability. However, both exercises were helpful in improving pain, and only knee alignment-oriented balance improved proprioception.

Keywords: Knee alignment, Oriented balance exercises, Conventional balance exercises, Patellofemoral pain syndrome, Proprioception.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is the most prevalent musculoskeletal condition encountered by orthopedic physical therapists as well as one of the most prevalent causes of anterior knee pain due to multiple factors **(1).** Some of these factors are movement-related factors that can be identified by executing tasks that require knee flexion exceeding 60° and knee movement preceding toes **(2)**. Additional contributors to PFPS include bone malalignment, imbalances in the muscles of the knee, instability in the quadriceps or gluteal muscles, loss of proprioception, impaired neuromuscular control, and altered biomechanical processes of the lower extremity **(3-5).** In contrast with the population as a whole, which experiences an incidence of 22.7% per year, current systematic reviews have identified a prevalence of PFP among adolescents at 28.9% per 1,000 person-years. Although this review incorporated studies that predominantly focused on highly active populations, such as military recruits along with athletes, the participants encompassed a range of ages **(6)**. Engaging in physical activities such as running, jumping, squatting, or prolonged periods of sitting with the knees bent can exacerbate the excruciating pain experienced in the peripatellar region, which is an outcome of overuse injury **(7)**. A critical aspect of patient care for individuals with PFPS involves the assessment and management of diminished proprioceptive function and neuromuscular control, both of which are associated with alterations in the lower extremity biomechanics (dynamic knee valgus) **(8).** Dynamic knee valgus is believed to be strongly associated with PFPS due to its impact on reducing the contact area between the patella and the trochlea, leading to increased pressure on the patellofemoral joint. This increased pressure can induce overloading on the subchondral bone and nearby soft tissues **(9).**

Erdoganoglu *et al.* **(10)** Found that balance and functionality were affected in patients with PFPS due to pain and abnormal lower limb alignment. Another study by **Motealleh *et al.*** **(11)** discovered that balance is affected in those with PFPS and other muscular-skeletal disorders in addition to its importance in daily activities Thus, patellofemoral joint rehabilitation programs must include it. Also, many previous studies have found that PFPS patients have impaired postural stability, as a result, treatment options for these patients have included balancing exercise therapy **(12-14)**. A knee alignment-oriented balance exercise would involve keeping the knee from moving laterally or medially while standing on one leg, and keeping the pelvis as well as shoulders level to avoid patellar mal tracing **(15)**.

This study intended to compare alterations regarding proprioception (dynamic postural stability), as well as pain intensity (VAS) among PFPS patients having

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dynamic valgus knee managed with knee alignment-oriented balance exercises versus conventional balance exercises. We hypothesized that there would be no substantial difference in all parameters in the knee alignment-oriented balance group, contrasted to the conventional balance group.

PATIENTS AND METHODS

Study design: randomized control trial of patients diagnosed and referred to as having PFPS, conducted at the Faculty of Physical Therapy, Misr University for Science andTechnology, Egypt, participants were chosen using a suitable sampling approach, and the study was carried out from August 5, 2023, to February 10, 2024.

Study participants: The study's sample size was determined based on an alpha value of 0.05, an appropriate power of 80%, with a high effect size (d= 0.89). The study required a total of 34 participants (G * Power, version 3.1.9.4). The subjects were divided into two categories: 17 were given knee alignment-oriented balance exercises while the other 17 were given conventional balance exercises.

The inclusion criteria: The patient's age was between 18-35 years old of both gender and reported a pain intensity of 3 out of 10 on VAS while engaging in exercise in the past week [16]. Gradual development of pain in the front of the knee lasting more than 12 weeks [17].

Exclusion criteria: The patient had a medical history that included a patellofemoral dislocation or subluxation, radiologically proven knee osteoarthritis, knee joint effusion, as well as possibly other injuries or pain in the hips or back [17]**.** Patients having a pacemaker, epilepsy, serious malignancies, kidney stones, disc or spinal lesions, acute arthritis, recent surgery, severe fractures, or cardiovascular illness were also excluded [16]**.**

Instruments:

Visual analog scale (VAS), Biodex Stability System (Biodex balance system, united states, model 950-440-A700 *12.1"* BALANCE SD DISPLAY ASSEMBLY), and the Kinovea software v0.8.26 (Kinovea open-source project under GPLv2).

Methods and procedures:

Dynamic knee valgus was evaluated using a two-dimensional video analysis with Kinovea software v0.8.26, an open-source project under GPLv2, to measure the FPPA. The video camera was positioned 50 cm above the ground, 3 meters in front of the subject, to capture the maximum FPPA throughout the Single-Legged Drop Jump test [18, 19]**.** Participants were required to jump to their maximum height and land on one leg from a 50 cm high box. The right leg was used first, then followed by the left leg **as shown in figure 1** [20]**.**

Figure. 1: Dynamic knee valgus with Kinovea software**.**

The extent of pain severity was evaluated using the VAS [1]. The VAS scores varied from 0 (representing absence of pain) to 10 points (representing the most severe discomfort). The respondent fills out the pain Visual Analog Scale (VAS) themselves. At the same spot where the respondent's pain level was shown, they were asked to draw a line that is perpendicular to the VAS line. To determine the score, a 10-centimeter line was used to measure the distance in mm that separates the "no pain" anchor as well as the patient's mark. A score ranging from 0 to 10 was then produced.

To evaluate proprioception, we examined dynamic postural stability via the Biodex Stability System, often known as the Biodex balancing system [21]**.** Because individuals with PFPS were unable to finish the test while standing on their affected leg at levels lower than 4, we set the stability level for the current study between levels 4 and 8. Each participant was instructed to stand barefoot, while maintaining an unsupported foot beneath their weight-bearing ankle along with placing both of their hands concurrently on their iliac crests. They were instructed to keep their center of pressure within the balance zone, represented by the narrowest concentric ring on the biodex balance system display [22]**.**

After locking the platform, the examiner noted the participant's foot position by recording their coordinates as an array of (x, y) points on the platform. X represents the tilt around the AP axis, while Y represents the tilt around the ML axis. Additionally, the third metatarsal's angle with respect to the y-axis was carefully noted. Participants were directed to keep their testing foot on the platform throughout the trials. Each subject performed a 2-minute practice trial before being asked to complete static as well as dynamic balance tests. The same evaluator observed each test individually. Participants were directed to focus their gaze on the device screen in order to sustain the point at the center as accurately as feasible. The measurements each took 20 seconds, were carried out three times, and the average results were used for analysis. Each participant had to start the test over if they made contact with the handrails using their arms or

lowered their non-weight-bearing foot. A one-minute pause was provided to participants between tests to avoid fatigue Figure 2 [23].

Fig. (2): Assessment of dynamic postural stability.

Intervention:

Knee-alignment oriented balance exercises: While doing both static as well as dynamic balance exercises, participants wore a thigh strap equipped with a laser pointer. With the use of the laser pointer, the patients ware guided to position themselves along the center line (Figure 3) [24].

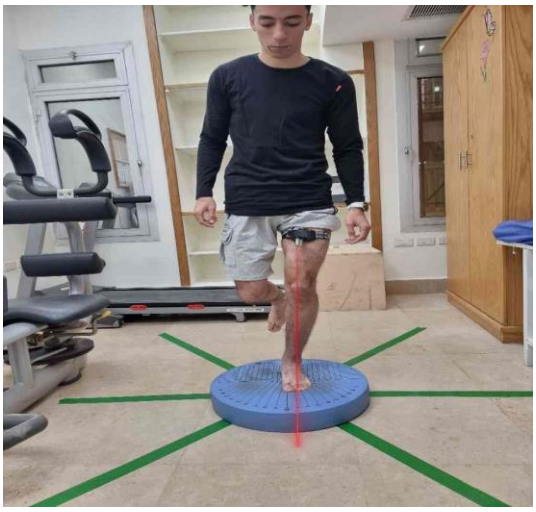

Figure 3: knee alignment-oriented balance.

Conventional balance exercises: They included both static as well as dynamic balance. Ten sets of the static balance exercise were performed by flexing the knees to 45 degrees for 20 seconds with both hands on the waist. If participants had difficulty maintaining balance during standing on one leg, an aid was provided, and assistance was reduced with time [25].

Dynamic balance exercise: exercises requiring reaching in multiple directions, like the star excursion test. The patient holds a static posture while moving the non-symptomatic limb in various directions such as anterior, anterolateral, posterior, posteromedial, as well as posterolateral. Ten sets of this exercise were completed as shown in figure 4(A) and (B) [26].

Figure 4: (A) static balance, (B) dynamic balance

Traditional rehabilitation treatment: one- and two-legged squats, single-leg lunges, wall sits or either wall slides, and side-lying hip abduction were prescribed for both groups as shown in figure 5 (A, B, C, D, F) [27].

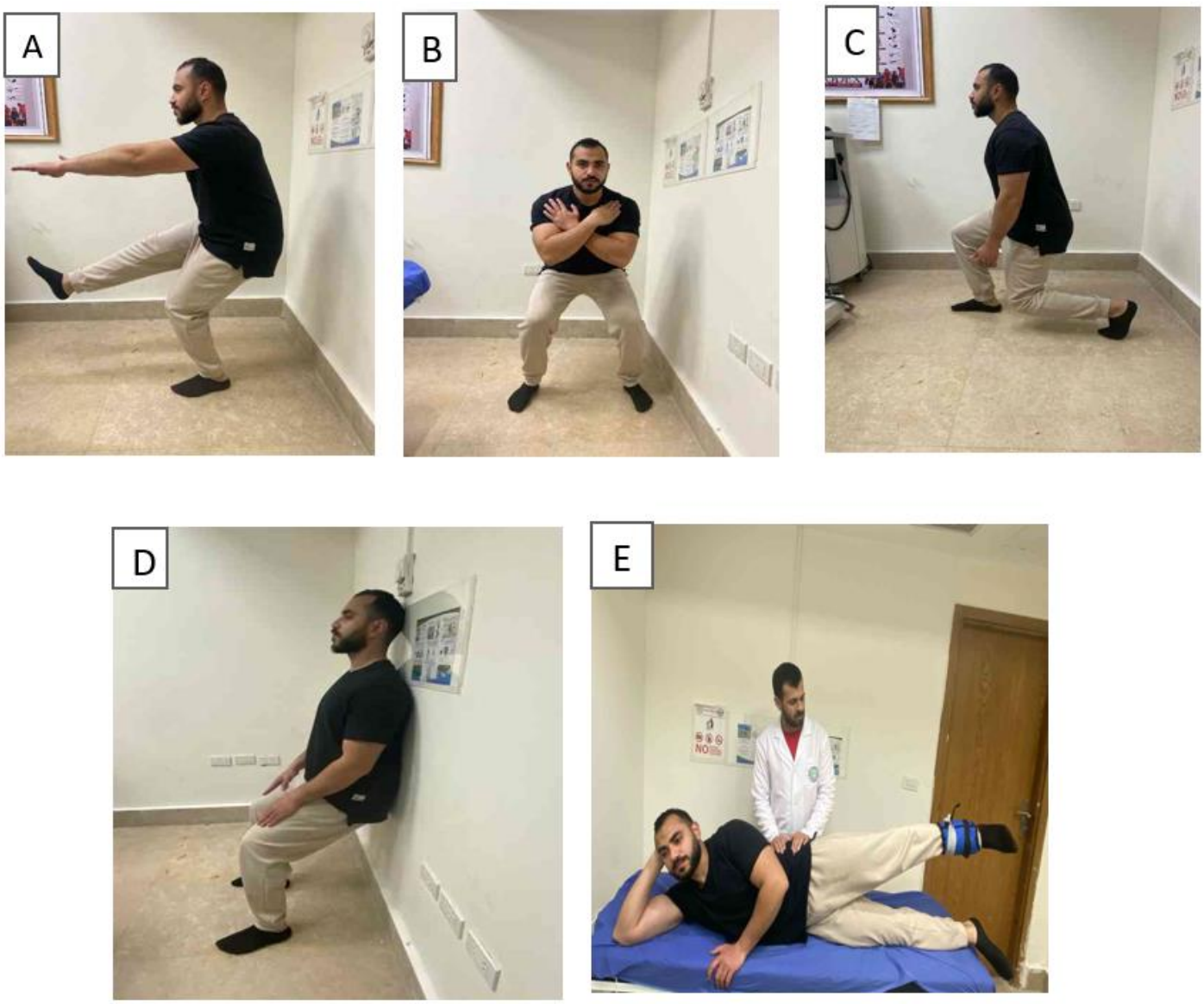

Figure 5: (A) One -legged squats, (B) two -legged squats, (C) single-leg lunges, (D) wall slides, (E) side-lying hip abduction.

Ethical approval:

Written informed consent was obtained from all patients before to their participation in the trial.

The study has received approval from the Research Ethical Committee of the Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/005064). The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis

The statistical analysis was carried out via the SPSS program Version 16 for Windows. Before doing the final analysis, the data were assessed for normal distribution and the existence of outliers. Means as well as standard deviations were calculated for all variables. P value less than 0.05 was considered significant. Independent samples t test, Paired t test, Pearson correlation coefficient, Kolmogrov Smirnov normality test were used.

RESULTS

Our data showed that there was no substantial difference among groups in demographic data (age and gender) nor medical data (Dynamic knee valgus, affected side, and duration of illness), denoting that both groups were homogenous. The post-measurement results for both groups indicate that none of the differences between the two groups' post-measurements were statistically substantial. The post-means of the two groups were very comparable.

Table (1): Test of normality (Kolmogrov-Smirnov test) for study variables

Variables	Z-value	p
VAS	0.683	0.739
overall	0.931	0.351
Anterior/Posterior Index	0.894	0.400
Medial Lateral Index	1.237	0.094
ACCELERATION TIME	0.958	0.318
PEAK TQ/BW	0.799	0.545

Table 1 shows that all the study variables are normally distributed as the assumption of normality was accepted for all variables.

Table (2): reveals that there was no substantial difference among VAS of both groups pre and post but for each group, there was a substantial decline in VAS. The table show that for the knee alignment group, the mean VAS declined from 6.44 to 3.57 while for the conventional balance group the mean VAS declined from 7.18 to 2.85. The mean decrease in the first group was 2.87 versus 4.33 in the second group.

Table (2): VAS of both groups pre and post

Time	**Knee alignment -oriented balance (n=17)**		**Conventional balance (n=17)**		**Difference between groups**		
	Mean	SD	Mean	SD	Difference	t	p
Pre	6.44	1.53	7.18	1.7	-0.74	1.33	0.19
Post	3.57	1.39	2.85	1.12	0.72	1.66	0.1
Mean Difference	2.87		4.33				
t	5.69		8.72				
p	0.0001*		0.0001*				

*: Significant .

Table (3): reveals that there was no substantial difference among dynamic postural stability of both groups but for the knee alignment group, there was a substantial decline in Anterior/Posterior Index. The table also shows that for the conventional balance group, there was no substantial difference among pre as well as post dynamic postural stability. Although all the mean post values were less than the pre mean values for both groups regarding overall, anterior/posterior index as well as medial lateral index, there was no significant difference except for the anterior/posterior index of the knee alignment group.

Table (3): Dynamic postural stability of both groups pre and post

Dynamic postural stability	**Knee alignment-oriented balance(n=17)**						**Conventional balance(n=17)**						**Difference among groups**	
	Pre		Post		t	p	Pre		Post		t	p	t	p
	Mean	SD	Mean	SD			Mean	SD	Mean	SD				
overall	2.29	1.08	1.65	0.75	2.01	0.052	2.22	0.95	1.78	0.97	1.33	0.195	0.44	0.665
Anterior/ Posterior Index	1.52	0.70	1.03	0.33	2.60	0.014 *	1.44	0.68	1.24	0.70	0.88	0.388	1.10	0.280
Medial Lateral Index	1.41	0.86	1.05	0.75	1.94	0.204	1.34	0.73	0.99	0.59	1.94	0.143	1.94	0.801

*: Significant

Table (4): shows that there was a substantial direct positive correlation among VAS as well as overall, Anterior/Posterior Index, and in addition Medial Lateral Index.

Table (4): Correlation among VAS and study variables

study variables	VAS	
	r	p
Overall	0.39	0.001*
Anterior/Posterior Index	0.34	0.004*
Medial Lateral Index	0.35	0.003*

*Significant at p-value<0.05

DISCUSSION

The objective of the present study was to compare the efficacy of conventional balance exercises as well as knee-alignment oriented balance exercises in conjunction with traditional rehabilitation treatment for patients with dynamic knee valgus who were diagnosed with patellofemoral pain syndrome.

Current result revealed that there was no statistically substantial difference among both groups for VAS, as well as dynamic postural stability with (p-value>0.05) and the post-means of the two groups were very comparable. There was a substantial decline in VAS (p=0.0001) in terms of both categories. However, there was no substantial difference in dynamic posture stability among the two groups in terms of overall, anterior/posterior index, as well as medial-lateral index, except for the knee alignment-oriented balance group's anterior/posterior index, which decreased significantly (p=0.014). Finally, there was a substantial direct positive association between VAS and the overall, anterior/posterior, as well as medial lateral indices. The findings of the recent research are congruent with the outcomes of a study by **Lee *et al.***, who contrasted among knee alignment-oriented static as well as dynamic balance exercise and found that compared to static balancing exercises focused on knee alignment, dynamic balance exercises can potentially improve reaction time in the quadriceps muscles and dynamic postural stability. However, patient-reported outcomes, response time and strength of the quadriceps muscles, and dynamic postural stability were all positively impacted by both kinds of balance exercises. Consequently, the results of the study conducted by **Lee *et al.***, are like our study for the part related to pain intensity and posture stability of the knee alignment-oriented group [(24)].

The findings of current study were in line also with the study conducted by **Guney *et al.*** [(28)] in that balance exercises mimicking squats improved pain as well as function in people having PFP by contracting the quadriceps muscle eccentrically, and most of the exercises in this study are similar to squats exercises.

Improvements in pain and quadriceps muscular strength are essential outcomes of the conservative therapy approach for individuals with PFPS, which encompasses both the hip and quadriceps muscles [(29)].

Previous studies have linked pain intensity to postural stability. Thus, improving these areas can directly impact pain intensity [(28,30)]. The current study, as mentioned before, revealed an enhancement in pain intensity, but no enhancement in dynamic postural stability, except in the knee alignment group where there was a significant decrease in Anterior/Posterior Index.

Aminaka and Gribble [(31)] studied how knee pain affects postural control in individuals with PFPS using the balance as well as reach test. They discovered that patellar strapping lowers knee pain and also it improves Star Excursion Balance Test balance performance in PFPS patients having poor balance in the anterior direction. Just as our research results showed, there was a significant direct positive correlation among VAS with overall, Anterior/Posterior Index, as well as Medial Lateral Index (decrease the index means improvement in posture stability). Contrary to the current results and the previous study, **Bennell and Hinman** [(32)] found that in healthy older people, acute knee pain had no significant effect on balance. In their research, the dynamic postural balance values of both limbs were identical.

CONCLUSION

From the outcomes of the recent study, it can be determined that there was no substantial difference among the knee alignment-oriented balance exercises and the conventional balance exercises regarding pain intensity and dynamic postural stability. However, both exercises effectively improved pain, and only knee alignment-oriented balance improved proprioception.

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- **Conflicts of interest:** There are no conflicts of interest, according to the authors.

REFERENCES

1. **Willy W, Hoglund T, Barton J *et al.* (2019):** Patellofemoral pain. The Journal of Orthopaedic and Sports Physical Therapy, 49(9): CPG1–CPG95.
2. **Crossley M, Cowan M, Bennell L *et al.* (2004):** Knee flexion during stair ambulation is altered in individuals with patellofemoral pain. Journal of Orthopaedic Research, 22(2): 267–274.
3. **Crossley M, van Middelkoop M, Barton J *et al.* (2019):** Rethinking patellofemoral pain: Prevention, management and long-term consequences. Best Practice & Research. Clinical Rheumatology, 33(1): 48–65.
4. **Lovalekar M, Perlsweig A, Keenan A *et al.* (2017):** Epidemiology of musculoskeletal injuries sustained by Naval Special Forces Operators and students. Journal of Science and Medicine in Sport, 20 (4): S51–S56.
5. **Maclachlan R, Collins J, Matthews G *et al.* (2016):** The psychological features of patellofemoral pain: a systematic review. https://doi.org/10.1136/bjsports-2016-096705

6. **Smith E, Selfe J, Thacker D *et al.* (2018):** Incidence and prevalence of patellofemoral pain: A systematic review and meta-analysis. PLOS One, 13(1): e0190892–e0190892.
7. **Halabchi F, Mazaheri R, Seif-Barghi T (2013):** Patellofemoral pain syndrome and modifiable intrinsic risk factors; how to assess and address? Asian Journal of Sports Medicine, 4(2): 85–100.
8. **Nakagawa H, Moriya U, MacIel D *et al.* (2012):** Frontal plane biomechanics in males and females with and without patellofemoral pain. Medicine and Science in Sports and Exercise, 44(9): 1747–1755.
9. **Powers M, Ward R, Fredericson M (2013):** Knee extension in persons with lateral subluxation of the patella: a preliminary study. Journal of Orthopaedic and Sports Physical Therapy, 33(11): 677–685.
10. **Erdoganoglu Y, Pepe M, Kaya D *et al.* (2020):** Lower extremity alignment due to patellofemoral syndrome and dynamic postural balance. Journal of Orthopaedic Surgery, 28(1): 1–6.
11. **Motealleh A, Mohamadi M, Moghadam B *et al.* (2019):** Effects of core neuromuscular training on pain, balance, and functional performance in women with patellofemoral pain syndrome: A clinical trial. Journal of Chiropractic Medicine, 18(1): 9–18.
12. **Bily W, Trimmel L, Mödlin M *et al.* (2008):** Training program and additional electric muscle stimulation for patellofemoral pain syndrome: a pilot study. Archives of Physical Medicine and Rehabilitation, 89(7): 1230–1236.
13. **Clijsen R, Fuchs J, Taeymans J (2014):** Effectiveness of exercise therapy in treatment of patients with patellofemoral pain syndrome: systematic review and meta-analysis. Physical Therapy, 94(12): 1697–1708.
14. **de Moura Campos Carvalho-e-Silva P, Peixoto Leão Almeida G, Oliveira Magalhães M *et al.* (2016):** Dynamic postural stability and muscle strength in patellofemoral pain: Is there a correlation? The Knee, 23(4): 616–621.
15. **Harris-Hayes M, Steger-May K, Koh C *et al.* (2014):** Classification of lower extremity movement patterns based on visual assessment: reliability and correlation with 2-dimensional video analysis. Journal of Athletic Training, 49(3): 304–310.
16. **Wu Z, Zou Z, Zhong J *et al.* (2022):** Effects of whole-body vibration plus hip-knee muscle strengthening training on adult patellofemoral pain syndrome: a randomized controlled trial. Disability and Rehabilitation, 144(20): 6017–6025.
17. **Yañez-Álvarez A, Bermúdez-Pulgarín B, Hernández-Sánchez S *et al.* (2020):** Effects of exercise combined with whole body vibration in patients with patellofemoral pain syndrome: a randomised-controlled clinical trial. BMC Musculoskeletal Disorders, 21(1): 582. doi: 10.1186/s12891-020-03599-2.
18. **Gwynne R and Curran A (2014):** Quantifying frontal plane knee motion during single limb squats: reliability and validity of 2-dimensional measures. International Journal of Sports Physical Therapy, 9(7): 898–906.
19. **Puig-Diví A, Escalona-Marfil C, Padullés-Riu M *et al.* (2019):** Validity and reliability of the Kinovea program in obtaining angles and distances using coordinates in 4 perspectives. PLoS ONE, 14(6): 1–14.
20. **Llurda-Almuzara L, Pérez-Bellmunt A, López-de-Celis C *et al.* (2020**): Normative data and correlation between dynamic knee valgus and neuromuscular response among healthy active males: a cross-sectional study. Scientific Reports, 10(1): 1–10.
21. **Lee H, Heo W, Lee H (2018):** Comparative postural stability in patients with lateral meniscus versus medial meniscus tears. The Knee, 25(2): 256–261.
22. **Karimi N, Ebrahimi I, Kahrizi S *et al.* (2008):** Reliability of postural balance evaluation using the biodex balance system in subjects with and without low back pain. JPMI - Journal of Postgraduate Medical Institute, 22(2): 95–101.
23. **Akhbari B, Salavati M, Mohammadi F *et al.* (2015):** Intra- and inter-session reliability of static and dynamic postural control in participants with and without patellofemoral pain syndrome. Physiotherapy Canada, 67(3): 248–253.
24. **Lee H, Shin H, Han B *et al.* (2022):** Prospective comparative study between knee alignment-oriented static and dynamic balance exercise in patellofemoral pain syndrome patients with dynamic knee valgus. Medicine (United States), 101(37): e30631. doi: 10.1097/MD.0000000000030631. PMID: 36123932; PMCID: PMC9478302.
25. **Sefton M, Yarar C, Hicks-Little A *et al.* (2011):** Six weeks of balance training improves sensorimotor function in individuals with chronic ankle instability. Journal of Orthopaedic and Sports Physical Therapy, 41(2): 81–89.
26. **Risberg A, Mørk M, Jenssen K *et al.* (2001):** Design and implementation of a neuromuscular training program following anterior cruciate ligament reconstruction. Journal of Orthopaedic and Sports Physical Therapy, 31(11): 620–631.
27. **Nakagawa H, Muniz B, Baldon R *et al.* (2008):** The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: A randomized controlled pilot study. Clinical Rehabilitation, 22(12): 1051–1060.
28. **Guney H, Yuksel I, Kaya D *et al.* (2016):** The relationship between quadriceps strength and joint position sense, functional outcome and painful activities in patellofemoral pain syndrome. Knee Surgery, Sports Traumatology, Arthroscopy, 24(9): 2966–2972.
29. **Crossley M, Stefanik J, Selfe J *et al.* (2016):** 2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 1: Terminology, definitions, clinical examination, natural history, patellofemoral osteoarthritis and patient-reported outcome m. British Journal of Sports Medicine, 50(14): 839–843.
30. **Hall M, Hinman S, van der Esch M *et al.* (2017):** Is the relationship between increased knee muscle strength and improved physical function following exercise dependent on baseline physical function status? Arthritis Research & Therapy, 19(1): 271.
31. **Aminaka N, Gribble A (2008):** Patellar taping, patellofemoral pain syndrome, lower extremity kinematics, and dynamic postural control. Journal of Athletic Training, 43(1): 21–28.
32. **Bennell L, Hinman S (2005):** Effect of experimentally induced knee pain on standing balance in healthy older individuals. Rheumatology, 44: 378–381.