

# Effects of Patellar Taping on the Patella Position in Presence of Quadriceps Contraction in 20-40 Year-Old Women With Patellofemoral Pain Syndrome Using MRI



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## ABSTRACT

**Objectives:** Patellar maltracking is the main reason for pain and disability in patellofemoral pain syndrome (PFPS). Patellar taping can considerably reduce such pain and disability. This study compared the effectiveness of physiotherapy exercises and kinesio taping on the patellar position in women with PFPS (mean age 32.2±1.12 years) by using magnetic resonance imaging (MRI).

**Methods:** Thirty women with a one-year history of PFPS took part in this study. MRI was done on the participant's patellofemoral joint at 30° knee flexion with quadriceps contraction in two stages: 1<sup>st</sup> stage-immediately after kinesio taping and 2<sup>nd</sup> stage-after 10 sessions of kinesio taping. The effectiveness of the interventions was determined by measuring the patellofemoral congruence angle (PFCA), lateral patellofemoral angle (LPFA), and lateral patellar displacement (LPD) in the MRI images.

**Results:** Statistical analysis revealed significantly reduced pain in all participants. The results showed a significant reduction in PFCA during quadriceps contraction immediately after kinesio taping, and a significant improvement was also observed in LPFA after 10 days of using kinesio taping by quadriceps contraction.

**Discussion:** Kinesio taping plus quadriceps contraction reduced the PFCA and LPFA. Patellar taping is effective in the correction of the patellar position in contracted quadriceps. Therefore, both neuromuscular and mechanical effects of patellar taping affect the patellar position over a long period. The combination of patellar taping and exercise reduced pain and improved activity faster than either of the treatment alone.

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## 1. Introduction

**P**atellofemoral pain syndrome (PFPS) is one of the most common knee complaints, particularly among the women [1]. This syndrome is characterized by initial retro patellar pain. Although its etiology has not been clearly established, PFPS has been correlated to several factors that cause patellar malalignment, such as lateral patellar tilt, lateral glide due to imbalance of the *Vastus medialis oblique* and *Vastus lateralis* muscles [2], rotation and posterior tilt of the inferior pole of the patella and shortening of the iliotibial tract [3, 28]. These factors enhance the quadriceps activity and lead to an imbalance in gait biomechanics and pain [4].

Under these altered biomechanical conditions, the odd facet of the patella comes into contact with the trochlear groove of the femur during the knee flexion [5]. In PFPS, the increase in the surface area of the patellofemoral joint leads to the generation of adequate disturbing forces in the knee and hence, reduces pain [6]. Mechanical displacement of the patella occurs due to certain factors, such as *Vastus medialis oblique* weakness, iliotibial tract shortening [3], patellofemoral dysfunction, increased Q angle [7], and lower extremity dysfunction such as coxa *Volga*, coxa *Vera*, femoral anteversion, and foot pronation [5]. In this study, we assessed the factors related to PFPS, which was defined as a dysfunction of the soft tissue present around the knee.

The *Vastus medialis oblique* seems to be the most important factor that prevents abnormal patellar tracking [8]. The treatment of PFPS, in addition to conventional treatment methods, involves a taping method introduced by McConnell. Taping leads to stretching of the shortened lateral knee compartment, improvement in the knee proprioception, correction of abnormal patellar position, and facilitation of *Vastus medialis oblique* function [9]. Patellar taping has been reported to correct [3] and maintain the position of the patella and reduce mechanical stress on the patellofemoral joint, resulting in facilitation of normal patellar tracking [10, 29].

In PFPS patients, patellar taping has been shown to significantly reduce joint pain [2, 11, 12] within a short time and during activities involving dynamic postural control [13]. The mechanism underlying the pain reduction involves increased skin excitability and changes in motor unit recruitment in the muscles around the knee joint [14], which improve muscle performance in PFPS patients. Such an improvement and the associated pain relief are related to the corrected patellar position [15],

patellofemoral joint improvement [16], and central nervous system excitability [17]. However, some authors have reported opposite results of taping on pain [6, 18]. Furthermore, some studies have reported that patellar taping does not affect the patellofemoral congruence angle (PFCA) in PFPS [19, 20], whereas others have reported that taping significantly improves this angle, but the effect decreases after 15 minutes of exercise [10, 21].

There are controversies on the mechanism of taping effect on PFPS. Some of the previous radiographic studies have showed that McConnell taping has mechanically corrected the patellar position. In the case of Kinesio taping, the force applied by taping does not seem to be enough to bring a mechanical change.

On the other hand, in functional situations, muscle contraction can easily deviate patella from its position and reduce the corrective effect of kinesio taping. However, the extent to which kinesio taping would be able to correct patellar position while quadriceps muscle is contracted remains a question. In order to evaluate these theories, this study assessed the effects of patellar taping on the patella position in the presence of quadriceps contraction in women with PFPS.

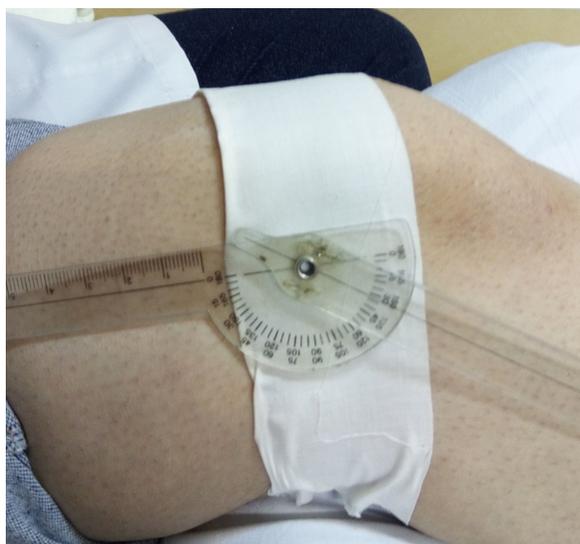
In this study, we attempted to (a) evaluate the short-term and long-term effects of kinesio taping, (b) assess whether kinesio taping can maintain the correct patellar position in the presence of quadriceps contraction, and (c) determine the optimal combination of a patellar taping method and exercise protocol that would be more effective than using either of the method alone.

## 2. Methods

Thirty women with a mean age of  $32.2 \pm 6.18$  years, a one-year history of PFPS, and without any history of neurological disorders participated in the study. Subjects satisfying the inclusion criteria signed a written consent to participate in the study. Informed consent was obtained from the Knee and Osteoarthritis Outcome Score (KOOS). A visual analog scale (VAS) was used to determine the pain levels before and after the treatment.

### Measurement of patella position on MRI

Magnetic resonance imaging (MRI) was used to evaluate patella tracking in a non-invasive way during relaxation and contraction of the quadriceps muscle. The MRI of the patella was performed in the Imaging center of ERFAN Hospital, Tehran. Axial plane of MRI images was performed using a coil fixed 1.5 T MRI scanners



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**Figure 1.** Taping patella position in MRI coil.

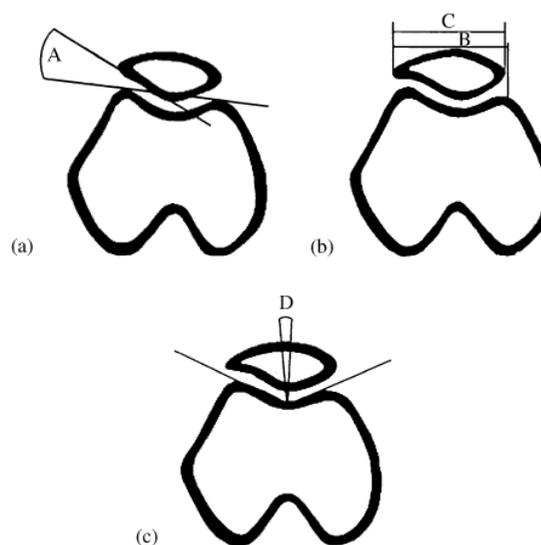
(EScan; SIEMENS, Avanto 2007, Germany). The patient lied supine on the MRI device bed. The test knee was positioned passively at 30 degrees of flexion by the examiner using the goniometer and then fixed at this position using a wedge under test knee. The other knee was placed relaxed on the MRI bed (Figure 1).

Imaging was performed using an axial T1 weighted 3D isotropic profile with the following parameters: (repetition time: 400 ms; echo time: 41 ms; flip angle: 150°; image matrix: 320 m<sup>2</sup>; slice thickness: 4-5 mm; interslice gap: 10% mm; field of view: 20 cm; number of signal averages: 2; Image acquisition time: 2.5 min (The patellofemoral joint was imaged by MRI in 30° knee flexion). The subjects lied supine, and a trained examiner used a goniometer to fix the patient's knee joint passively in 30° flexion (Figure 1).

The other leg was positioned alongside the magnets. The patellofemoral joint of the test leg was imaged in this position after the knee taping by using the medial glide technique (taping from the lateral to the medial border of the patella) in the presence of quadriceps contraction. MRI was repeated after 10 sessions of treatment for all participants in the presence of quadriceps contraction (Figure 1).

We used the most common radiographic measurements of patellar alignment, namely, lateral patellar displacement (LPD), lateral patellofemoral angle (LPFA), and PFCA. We selected the MRI slice with the largest patellar diameter as the reference image.

LPFA is the angle between a line joining the summits of the femoral condyles and a line joining the margins of the lateral facet of the patella (Figure 2.a). LPD is the



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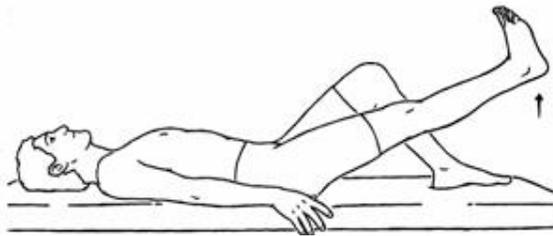
**Figure 2.** Radiographic measurements of patellar position. (a) Lateral patellofemoral angle (b) Lateral patellar displacement (c) Patellofemoral congruence angle [11].

displacement of the patella, in millimeters, in the frontal plane, relative to the position of the medial femoral condyle [16] (Figure 2.b). PFCA is the angle between the apex of the intercondylar sulcus and the lowest aspect of the patellar ridge [16] (Figure 2.c).



**Figure 3.** Patellar taping.

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Figure 4. Straight leg raising (SLR) test.

### Taping procedure

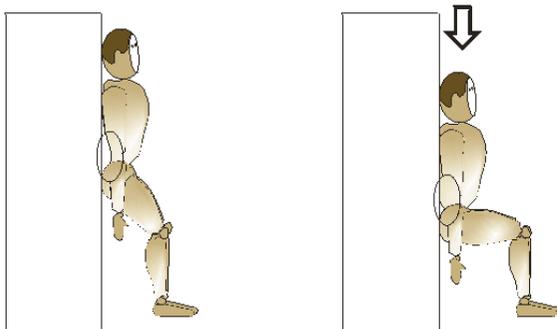
With the patient in supine position, the physiotherapist placed the test knee at 30° flexion position passively by using a goniometer. Before the taping, we measured the extent to which the tape could be stretched and marked the point on the knee that corresponded to 30% of the initial tape length. The first 5 cm of the tape (unstretched) was placed over the knee; the rest part of the tape, except for the last 5 cm, was stretched to its full extent and applied to the knee using a downward pressure technique in order to correct the patellar position. After taping, we assessed the range of knee flexion and extension to ensure that the joint movements were not restricted. The kinesio tape was replaced every two days by a trained examiner (Figure 3).

### Physical exercises

The patients were taught by a physiotherapist to do the mentioned exercises correctly. They were asked to repeat each one 15 times in two intervals per day for 10 days.

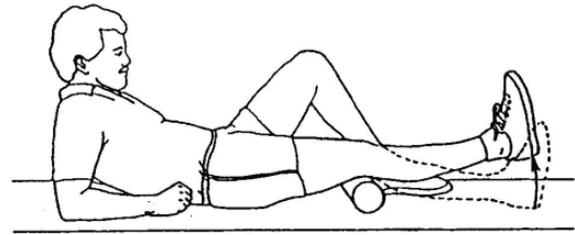
### Straight leg raising (SLR)

The subjects were asked to lie comfortably on a flat surface with their arms and hands by their side, and their legs lying flat (knees extended). The subjects raised one leg without bending the knee until the foot was just above their calf muscle. At this point, they tightened the quadriceps muscle of



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Figure 6. Half-squats.



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Figure 5. Terminal knee extension.

the raised leg to keep the leg straight. They then continued to slowly raise their leg to the level of their contralateral knee and then, slowly lowered it to the original position while keeping the quadriceps muscle contracted (Figure 4).

### Terminal knee extension

The subjects were asked to lie flat on their backs on the floor. A rolled up towel was placed under the test knee. The subjects then slowly straightened the test knee until that leg was no longer touching the towel. They held this position for 5 s and then brought the leg back down to the original position (Figure 5).

### Half-squats

To perform half-squats, the patients stood upright, with their feet placed firmly on the ground about shoulder width apart and their arms in front for maintaining the balance. Keeping the back straight, the subjects squatted down to attain the “sit on a chair” position until their thighs were parallel to the ground. They held this squatting position for 5 s and then slowly stood upright (Figure 6).

### Patellar mobilization

Medial glide was used to correct patellar lateralization; this involved raising the medial patellar border to correct the patellar tilt. Using a pincer grip, the subjects gently pushed their kneecaps towards their other leg, thus, raising the medial border of the patella (Figure 7).

### Image analysis

The axial MRI images obtained from the ERFAN scan center were saved on a CD and processed with the SIGNO software. We aimed to assess the ability of kinesio taping using the medial glide technique to first medialize the patella and then improve the patellar tracking in the presence of quadriceps contraction. For this purpose, we used the most common radiographic measurements of patellar alignment, namely, LPD, LPFA, and PFCA. We selected the MRI slice with the largest patellar diameter. Summary



Figure 7. Patellar mobilization. Iranian Rehabilitation Journal

of the participant's statistics obtained under 30° knee flexion before and after the treatment are shown in Table 1.

The repeated-measures analysis of variance (ANOVA) was used to test the effects of patellar taping and quadriceps contraction when changing the patella position during two sessions: 1) Immediately after taping, 2) Ten days after taping with quadriceps contracted in each group. To assess the reciprocal effects of different interventions between the groups, an independent t-test was used. An alpha level less than 0.05 was required to demonstrate a significant difference. The main factors

analyzed were changes in pain, as assessed on the VAS, and the changes in PFCA, LPFA, and LPD. A paired t-test was used to compare the pain levels recorded on the VAS before and after the interventions. The pain levels decreased significantly in all groups ( $P=0.02$ ) (Table 2).

### Measurements in the contracted-quadriceps condition

- PFCA: Repeated-measures ANOVA showed that in the contracted quadriceps condition, the PFCA significantly decreased after taping in the patellar taping group alone ( $P<0.05$ ).
- LPFA: It was found that LPFA in the contracted quadriceps condition significantly decreased after taping in the taping group and the taping plus exercise group ( $P>0.05$ ).
- LPD: It was found that in the contracted quadriceps condition, the LPD significantly decreased after taping in the taping plus exercise group on day 10 of the treatment ( $P<0.05$ ) (Table 3).

### 3. Results

Data were analyzed using Statistical Processing for the Social Science (Spss 16). A summary of descriptive statistics for 30° knee flexion, and 2 sessions (before and after treatment) are shown in Table 1.

Table 1. Summary of descriptive participants' statistics obtained under 30° knee flexion before and after the treatment.

Variable	Mean±SD	Mean±SD
	First Session	Last Session
Dominant thigh diameter	46.23±5.66	46.15±6.62
CLARK test	17 positive 13 negative	7 positive 23 negative
Quadriceps power	3.9±0.33	4.11±0.33
Abductor muscle power	3.6±0.36	4.1±4.4
VAS	5.33±2.44	3.8±2.57

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Table 2. Changes in VAS scores before and after the treatment.

	Mean	Std. Error Mean	Sig.
VAS before-VAS after	1.53	0.478	0.003

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**Table 3.** Changes in the patellar parameters during the contracted quadriceps condition.

Variable	Immediately After Taping (Mean±SD)	10 Days After Taping (Mean±SD)	Sig. (First and Last Measurement)
LPFA*	26.03±9.19	24.19±6.76	0.006
PFCA**	27.21±6.45	24.46±5.01	0.26
LPD***	5.62±1.91	4.94±1.73	0.11

\*Lateral patellofemoral angle, \*\*Patellofemoral congruence angle, \*\*\*Lateral patellar displacement.

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Repeated measurement of ANOVA was employed to test for evaluation the effects of taping and physical exercises, together or separately, during 3 sessions in each group. To assess reciprocal effects of different interventions between groups, Independent T-test was used. Alpha level less than 0.05 was required to demonstrate a significant difference.

The main factors measured were changes in pain on visual analog scale, PFCA, LPFA, LPD. Paired T-test used to compare pain in VAS, before and after interventions, showed decreased in pain level in all groups; however, it was significant just in taping group ( $P=0.02$ ) (Figure 5) In contracted quadriceps:

**PFCA:** Repeated measurement of ANOVA was used to compare PFCA changes in contracted quadriceps in groups. Results showed that only in taping group, immediately and 10 days after taping, PFCA decreased significantly ( $P<0.05$ ) (Figure 6).

PFCA changes normalized in groups and comparing with one way ANOVA test revealed that PFCA changes were not significant in groups ( $P>0.05$ )

**LPFA:** Repeated measurement of ANOVA was used to compare LPFA changes in contracted quadriceps, in groups. Results revealed that in taping and taping with physical exercise groups, during sessions, LPFA decreased significantly ( $P>0.05$ ) (Figure 7).

LPFA normalized in groups and comparing with one way ANOVA test revealed that LPFA changes in taping and taping with physical exercise groups, during sessions, were not significant ( $P>0.05$ )

**LPD:** Repeated measurement of ANOVA was used to compare LPD changes in contracted quadriceps, in groups. Results revealed that in taping with exercises groups, after 10 days taping, LPD decreased significantly ( $P<0.05$ ).

LPD normalized in groups and comparing with one way ANOVA test, revealed that LPD changes in taping

and taping with physical exercise groups, during sessions, decreased significantly ( $P<0.05$ ).

#### 4. Discussion

The limitations of this study included obtaining adequate financial resources for MRI and convincing the participants to pass all sessions correctly, which are sometimes very difficult. This study aimed at comparing the effects of patellar taping on the patella position in the presence of quadriceps contraction in 20 to 40-year-old women with PFPS using MRI.

Our results demonstrated that taping plus physical exercise rapidly decreased the pain and improved patellar tracking in PFPS. Our results are similar to those of some previous studies [2, 20, 25] that used the McConnell taping method. The mechanism underlying the pain reduction after taping involves an effect of taping with quadriceps contraction on the skin receptors [26, 27], excitability of the central nervous system [17, 26], and increased excitability of the Vastus medialis oblique [23].

In the contracted quadriceps condition, we observed that with decreased LPFA, both LPD and PFCA decreased. These results may be explained by the effect of muscle contraction on patellar tracking, the difference in motor unit recruitment in different parts of the quadriceps, and the enhancement of the effects of taping on patellar tracking by muscle contraction.

In our study, the PFCA decreased in the contracted quadriceps condition. These results differ from those of some previous studies [19, 20], and this difference may be related to the differences in the type of taping method used and muscle condition.

We found that muscle contraction during physical exercises decreased the LPFA and LPD in all participants in both measurement days. In the contracted quadriceps condition, taping plus physical exercise decreased the PFCA, LPFA, and LPD after 10 days of taping with

quadriceps contraction. These observations may be explained by the effect of prolonged physical exercise plus taping to facilitate neuromuscular function and enhancing mechanical and neural effects of long using kinesio taping to correct the patellar tracking and help overcome forces generated by muscle action acting against the joint. A previous study has reported that kinesio taping plus exercise did not improve PFPS [26], which contradicts with our findings. This contradiction may be related to the differences in the taping method. In spite of the similarity in the kind of taping and the procedure of patellar measurements, our measurements were obtained during quadriceps contraction in 30° knee flexion.

Most studies that evaluated the effect of patellar taping on patellar tracking have used the McConnell taping method [15, 22, 23]. This method has some limitations such as lower elasticity, the requirement of applying a pre-wrap tape under the main tape, and restriction of muscles and joint range of motion. The kinesio tape, invented by Kenzo Kase in 1996, has some benefits over the McConnell method as it is thin and elastic, does not restrict movement, and is easy to apply. Moreover, kinesio taping loads forces onto the skin, allowing full range of motion of the joints and the muscles around the joint. Patellar tracking after kinesio taping has been assessed in a previous study [24]; however, more research is required to determine the optimal taping method.

## 5. Conclusion

In contracted muscle, results showed that taping decreased LPD & PFCA. Physical exercises, after 10 days, decreased LPD. Taping with physical exercises, leads to decreasing LPFA & LPD. Some explanation for these observations are the effect of physical exercise with taping in long period which results in facilitation of neuromuscular system, correction in patella tracking, increased joint power to overcome forces to joint which are from muscle counteraction. results showed that the addition of kinesio taping to the exercises does not improve the results in PFPS patients., which in contrary to our result, is due to taping method, evaluating patella in relaxed and contracted muscles and degree of knee flexion assessing

We suggest that further researches should use perfectly trained therapist in order to measure the patella position correctly. We also recommend that the reference position of the patella, especially borders and angles, and the methods of measuring its angles need to be described perfectly so as to decrease the errors in measurements.

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## Conflict of Interest

The authors declared no conflict of interests.

## References

- [1] Nasrin N. [Physiotherapy in orthopedic disorder (Persian)]. 2<sup>nd</sup> ed. Tehran: Sobh-e Saadat; 2005.
- [2] Powers CM, Landel R, Sosnick T, Kirby J, Mengel K, Cheney A, et al. The effects of patellar taping on stride characteristics and joint motion in subjects with patellofemoral pain. *Journal of Orthopaedic & Sports Physical Therapy*. 1997; 26(6):286-91. doi: 10.2519/jospt.1997.26.6.286
- [3] Puniello MS. Iliotibial band tightness and medial patellar glide in patients with patellofemoral dysfunction. *Journal of Orthopaedic & Sports Physical Therapy*. 1993; 17(3):144-48. doi: 10.2519/jospt.1993.17.3.144
- [4] Neumann DA. *Kinesiology of the musculoskeletal system, foundation for physical rehabilitation*. 1<sup>st</sup> ed. Philadelphia: Mosby; 2004.
- [5] Connolly KD, Ronsky JL, Westover LM, Küpper JC, Frayne R. Differences in patellofemoral contact mechanics associated with patellofemoral pain syndrome. *Journal of Biomechanics*. 2009; 42(16):2802-807. doi: 10.1016/j.jbiomech.2009.07.028
- [6] Chen WC, Hong WH, Huang TF, Hsu HC. Effects of kinesio taping on the timing and ratio of vastus medialis obliquus and vastus lateralis muscle for person with patellofemoral pain. *Journal of Biomechanics*. 2007; 40:318. doi: 10.1016/j.jbiomech.2009.07.028
- [7] Ingersoll CD, Knight KL. Patellar location changes following EMG biofeedback or progressive resistive exercises. *Medicine & Science in Sports & Exercise*. 1991; 23(10):1122-127. doi: 10.1249/00005768-199110000-00002
- [8] McDonald R. *Taping techniques*. 2<sup>nd</sup> ed. Oxford: Elsevier; 2004.
- [9] Christou EA. Patellar taping increases vastus medialis oblique activity in the presence of patellofemoral pain. *Journal of Electromyography & Kinesiology*. 2004; 14(4):495-504. doi: 10.1016/j.jelekin.2003.10.007
- [10] Salsich GB, Brechter JH, Farwell D, Powers CM. The effects of patellar taping on knee kinetics, kinematics, and vastus lateralis muscle activity during stair ambulation in individuals with patellofemoral pain. *Journal of Orthopaedic & Sports Physical Therapy*. 2002; 32(1):3-10. doi: 10.2519/jospt.2002.32.1.3
- [11] Cowan SM, Bennell KL, Hodges PW. Therapeutic patellar taping changes the timing of vasti muscle activation in

- people with patellofemoral pain syndrome. *Clinical Journal of Sport Medicine*. 2002; 12(6):339-47. doi: 10.1097/00042752-200211000-00004
- [12] Aminaka N, Gribble PA. Patellar taping, patellofemoral pain syndrome, lower extremity kinematics, and dynamic postural control. *Journal of Athletic Training*. 2008; 43(1):21-28. doi: 10.4085/1062-6050-43.1.21
- [13] Gigante A, Pasquinelli FM, Paladini P, Ullisse S, Greco F. The effects of patellar taping on patellofemoral incongruence: A computed tomography study. *American Journal of Sports Medicine*. 2001; 29(1):88-92. PMID: 11206262
- [14] Herrington L. The effect of patella taping on quadriceps strength and functional performance in normal subjects. *Physical Therapy in Sport*. 2004; 5(1):33-36. doi: 10.1016/j.ptsp.2003.09.002
- [15] Crossley K, Cowan SM, Bennell KL, McConnell J. Patellar taping: is clinical success supported by scientific evidence? *Manual Therapy*. 2000; 5(3):142-50. doi: 10.1054/math.2000.0354
- [16] Fu TC, Wong AM, Pei YC, Wu KP, Chou SW, Lin YC. Effect of Kinesio taping on muscle strength in athletes—a pilot study. *Journal of Science and Medicine in Sport*. 2008; 11(2):198-201. doi: 10.1016/j.jsams.2007.02.011
- [17] Keet JH, Gray J, Harley Y, Lambert MI. The effect of medial patellar taping on pain, strength and neuromuscular recruitment in subjects with and without patellofemoral pain. *Physiotherapy*. 2007; 93(1):45-52. doi: 10.1016/j.physio.2006.06.006
- [18] Bockrath K, Wooden C, Worrell T, Ingersoll CD, Farr J. Effects of patella taping on patella position and perceived pain. *Medicine & Science in Sports & Exercise*; 1993; 25(9):989-92. PMID: 8231783
- [19] Ng GY, Cheng JM. The effects of patellar taping on pain and neuromuscular performance in subjects with patellofemoral pain syndrome. *Clinical Rehabilitation*. 2002; 16(8):821-7. doi: 10.1191/0269215502cr563oa
- [20] Doucette SA, Child DD. The Effect of Open and Closed Chain Exercise and Knee Joint Position on Patellar Tracking in Lateral Patellar Compression syndrome I. *Journal of Orthopaedic & Sports Physical Therapy*. 1996; 23(2):104-10. doi: 10.2519/jospt.1996.23.2.104
- [21] Pfeiffer RP, DeBeliso M, Shea KG, Kelley L, Irmischer B, Harris C. Kinematic MRI assessment of McConnell taping before and after exercise. *American Journal of Sports Medicine*. 2004; 32(3):621-28. doi: 10.1177/0363546503261693
- [22] Herrington L. The effect of patellar taping on quadriceps peak torque and perceived pain: a preliminary study. *Physical Therapy in Sport*. 2001; 2(1):23-28. doi: 10.1054/ptsp.2000.0034
- [23] McEwan I, Herrington L, Thom J. The validity of clinical measures of patella position. *Manual Therapy*. 2007; 12(3):226-30. doi: 10.1016/j.math.2006.06.013
- [24] Somes S, Worrell TW, Corey B, Ingersoll CD. Effects of patellar taping on patellar position in the open and closed kinetic chain: A preliminary study. *Sport Rehabilitation*. 1997; 6(4):299-308. doi: 10.1123/jsr.6.4.299
- [25] Akbaş E, Atay AO, Yüksel I. The effects of additional kinesio taping over exercise in the treatment of patellofemoral pain syndrome. *Acta Orthopaedica et Traumatologica Turcica*. 2010; 45(5):335-41. doi: 10.3944/AOTT.2011.2403
- [26] Portney, L, Watkins M. *Foundations of clinical research. Applications to practice*. New York: Prentice Hall; 1993.
- [27] Worrell T, Ingersoll CD, Bockrath-Pugliese K, Minis P. Effect of patellar taping and bracing on patellar position as determined by MRI in patients with patellofemoral pain. *Journal of Athletic Training*. 1998; 33(1):16-20. PMID: 16558478
- [28] Sokhangouei Y, Abdollahi I, Kazem-Dokht M, Karimlou M, Khanlari Z. [Measuring the quadriceps angle by a new method and comparison with goniometer and radiography (Persian)]. *Rehabilitation Journal*. 2012; 13(2):64-73.
- [29] Goharpey S, Fakour M, Khalesi V, Emrani A, Shaterzadeh M J. [The Relationship between Functional Tests and Knee Muscles Isokinetic Parameters in Patients with Patellofemoral Pain Syndrome (Persian)]. *Rehabilitation Journal*. 2007; 8(1):6-12.