

## [ Sports Physical Therapy ]

# Static Balance in Patients With Patellofemoral Pain Syndrome

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**Background:** The relationship between one-leg static standing balance (OLSSB) and patellofemoral pain syndrome (PFPS) is unknown.

**Hypothesis:** OLSSB decreases in patients with PFPS.

**Design:** Prospective case series.

**Methods:** Fifty-two women with unilateral PFPS were enrolled in this study. OLSSB was evaluated with a stabilometer. Q angle was measured with a lengthened-arm universal goniometer. Lower extremity alignment was analyzed with full-length standing anteroposterior teleroentgenograms. Quadriceps and hamstring strength was measured on an isokinetic dynamometer.

**Results:** There were significant differences in OLSSB, Q angle, and strength of quadriceps and hamstring between the symptomatic and asymptomatic sides. There was a correlation between the strength of the quadriceps and hamstring and OLSSB, while there was no correlation between OLSSB and the severity of pain, lower extremity alignment, and Q angle on the symptomatic side.

**Conclusions:** OLSSB and quadriceps and hamstring strength decreased and Q angle increased on the symptomatic side in PFPS patients. A relationship between OLSSB and pain, Q angle, and lower extremity alignment was not detected, while there was a correlation between the strength of the quadriceps and hamstring and OLSSB.

**Clinical Relevance:** A quadriceps and hamstring strengthening may be beneficial to improve OLSSB in patients with PFPS.

**Keywords:** balance; patellofemoral pain; muscle strength; Q angle; malalignment

Postural control is the ability to maintain the body's center of gravity over the base of support; it is a basic requirement for independent mobility in daily life.<sup>12,20</sup> The maintenance of this complex process depends on the vestibular system, age, pain, vision, body shape, visual-spatial perception, tactile input, agility, proprioception, and the musculoskeletal and neuromuscular systems.<sup>18</sup> Any insufficiency of this complex may result in imbalance.

Patellofemoral pain syndrome (PFPS) is one of the most common problems of the knee joint.<sup>26,35</sup> There are several causal factors described for PFPS, such as leg length discrepancy, angular and rotational deformities of the lower extremity, musculature tightness, weakness or imbalance, large quadriceps (Q) angle, abnormal patellar mobility or foot morphology,

and even hallux valgus. Patellar malalignment is one of these factors.<sup>33</sup> The Q angle is a common objective measurement of the patellar alignment. Many authors report that a greater Q angle ( $> 20^\circ$ ) is a risk factor for developing PFPS.<sup>13,23,26</sup> Witvrouw et al<sup>36</sup> and Duffey et al<sup>7</sup> do not support this finding. Lower extremity alignment is another factor in PFPS.<sup>7,29,30</sup> Lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA) are also indicators of lower extremity alignment.<sup>24,28</sup>

Decreased hamstring and quadriceps muscle strength is also a factor in patients with PFPS.<sup>3,5,28</sup> The hamstring:quadriceps muscle strength ratio relates to lower extremity balance.<sup>14,16</sup> Muscle deficits<sup>27,34</sup> and pain<sup>4,9</sup> could affect standing balance in PFPS patients. Therefore, the aim of this study was to assess one-leg static standing balance (OLSSB) and related parameters

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Table 1. Demographic and clinical characteristics.

Variable	Mean $\pm$ SD
Age, y	42.01 $\pm$ 10.11
Height, cm	160.94 $\pm$ 6.34
Weight, kg	72.73 $\pm$ 10.96
Body mass index, kg/m <sup>2</sup>	28.15 $\pm$ 4.65
Duration of symptoms, mo	11.94 $\pm$ 2.75
Pain, symptomatic side	6.08 $\pm$ 2.64

with OLSSB, such as hamstring and quadriceps strength, Q angle, LDFA, and MTPA, in patients with PFPS. The hypothesis of this study was that standing balance decreases on the symptomatic side in patients with PFPS.

## METHODS

### Patients

Fifty-two women who had unilateral knee pain were evaluated (mean age, 42.01  $\pm$  10.11 years) (Table 1). Ethical approval was obtained from the local ethical committee. Written informed consent was obtained from all patients. Patients were included in this study if the following criteria were fulfilled: onset of pain longer than 6 months; no neurologic or vision problem; positive clinical signs of the syndrome (ie, retro patellar pain, crepitation, pain in patellar grinding, Clarke sign, active patellar grind test, direct patellar compression, palpation of the lateral-medial articular border of the patella); no history or clinical evidence of patellofemoral dislocation, subluxation, lower extremity surgery, trauma, or physical therapy for syndrome.<sup>19,22</sup> Absence of knee ligaments, bursae, menisci, and synovial plicae cartilage lesions was confirmed by magnetic resonance imaging assessment.

### Assessments

**Lower extremity malalignment.** The lower extremity alignment was evaluated with LDFA and MPTA by full-length standing anteroposterior teleroentgenogram. A radiograph of the lower extremities was taken with bare feet. The patient was positioned with the knee in full extension. Weight was distributed equally over both extremities. The tibial tuberosity was positioned toward the beam. Intraobserver and interobserver reliabilities of the LDFA and MPTA were found to be excellent regardless of the observer's experience.<sup>10</sup> LDFA is formed by intersecting the femoral anatomic axis with the tangent to the femoral condyles in the frontal plane (normal range, 85°-90°).<sup>25</sup> MPTA is formed by intersecting the tibial

anatomic axis with the tangent to the tibial plateau in the frontal plane (normal range, 85°-90°).<sup>25</sup>

**Q angle.** Q angle was measured with a lengthened-arm 360° plastic universal goniometer. Patients were positioned supine with toes pointing vertically (knee extended and quadriceps muscle relaxed). The center of the patella, the tibial tuberosity, and the anterior superior iliac spine were painted with a marker. The pivot of the goniometer was placed on the center of the patella. The long arms of the goniometry were placed on the tibial tuberosity and the anterior superior iliac spine. The angle where these lines intersect was regarded as the Q angle.<sup>11</sup>

**Balance score.** Balance was evaluated with an instrumented balance assessment system (Kinesthetic Ability Trainer 4000, Berg, Inc, San Marcos, California). The testing technique<sup>32</sup> comprised a circular platform with varying degrees of stability, centered on a small pivot. All tests were carried out at a uniform hydraulic pressure of 6 psi. A numerical score was based on the test time and the deviation distance from the center of the platform, measured every second. The estimated time and distance are denoted by the Balance Index Score, which represents the combined coordinate position of all data acquired during the static balance tests: A low score indicates good balance<sup>6,31</sup>; a score above 500 is a poor result. Patients performed the tests with bare feet, knees extended, and arms crossed at their chests. Each patient was given at least a 5-minute practice period to become familiar with the device. Three consecutive static balance trials were conducted on both feet, followed by a 30-second test on the symptomatic and asymptomatic sides. Between each test, there was 1 minute of rest. Verbal encouragement was not given during the test.<sup>31</sup> The average of 3 repetitions was analyzed.

**Pain.** An 11-point numeric rating scale (1-cm intervals) was used to assess pain during the balance test, from *no pain* to *worst imaginable pain*.<sup>17</sup>

**Muscle torque.** Warm-up exercises were used before data collection. The peak torque of the quadriceps and hamstring muscles was recorded bilaterally on an isokinetic dynamometer (Biodex Pro3, Biodex, New York, New York) at angular velocities of 60° per second. Testing was performed seated at 70° of hip flexion (from supine) and the knee at 90° of flexion in a standard fashion. The monitor provided visual feedback. Standardized verbal encouragement was given during the test performance. Three repetitions at 60° per second were performed.<sup>8</sup>

### Statistical Analysis

Normality of the data distribution was confirmed by Kolmogorov-Smirnov testing with  $\alpha$  set at 0.05. All data were analyzed with the SPSS 16 (IBM, Armonk, New York). The paired sample *t* test was used to determine the difference between the symptomatic and asymptomatic sides. The percentage of the strength loss was analyzed with 95%

Table 2. Differences between the symptomatic and asymptomatic sides: mean  $\pm$  SD.

Variable	Symptomatic	Asymptomatic	<i>P</i> <sup>a</sup>
Balance score	523.08 $\pm$ 202.06	438.49 $\pm$ 166.49	<0.01
Lateral distal femoral angle	87.54° $\pm$ 1.87°	87.62° $\pm$ 2.19°	0.80
Medial tibial proximal angle	87.56° $\pm$ 1.91°	87.46° $\pm$ 1.97°	0.73
Q angle	21.82° $\pm$ 3.32°	20.67° $\pm$ 4.24°	0.02
Quadriceps femoris strength (60 deg/s), N·m	70.96 $\pm$ 18.57	88.17 $\pm$ 22.65	0.01
Hamstring strength (60 deg/s), N·m	42.23 $\pm$ 12.06	54.52 $\pm$ 19.15	<0.01

<sup>a</sup>Paired sample *t* test (*P* < 0.05).

confidence intervals. The relationship between the parameters and balance scores was evaluated with the Pearson correlation coefficient test. Statistical significance was set at *P* < 0.05.

## RESULTS

Standing balance on the symptomatic side was significantly worse than on the asymptomatic side (*P* < 0.01). There was no difference in LDFA and MPTA between the symptomatic and asymptomatic sides (LDFA, *P* = 0.80; MPTA, *P* = 0.73). The Q angle of the symptomatic side was significantly higher than on the asymptomatic side (*P* = 0.02). Strength of the quadriceps (95% confidence interval, 51.92%, 27 patients) and hamstring (95% confidence interval, 63.46%, 33 patients) on the symptomatic side was lower than on the asymptomatic side at 60° per second (*P* < 0.01 and *P* < 0.01, respectively (Table 2)). No relationship was found between OLSSB and knee pain (*r* = 0.084, *P* = 0.55), Q angle (*r* = 0.180, *P* = 0.20), LDFA (*r* = 0.251, *P* = 0.07), and MTPA (*r* = -0.172, *P* = 0.22). Quadriceps (*r* = -0.294, *P* = 0.03) and hamstring (*r* = 0.352, *P* = 0.01) strength was related to OLSSB on the symptomatic side (Table 3).

## DISCUSSION

The most important finding of this study was that OLSSB and quadriceps and hamstring strength decreased and Q angle increased on the symptomatic side in patients with PFPS. In addition, quadriceps and hamstring muscle strength was related to OLSSB score. The severity of knee pain, LDFA, MTPA, and Q angle did not relate to OLSSB.

Loudon et al<sup>21</sup> and Aminaka and Gribble<sup>1</sup> investigated the effects of pain on postural control in patients with PFPS, showing the relationship between knee pain and the balance and reach test. Aminaka and Gribble<sup>1</sup> determined that patellar taping decreased knee pain and improved star excursion

Table 3. Parameters correlated with one-leg static standing balance score on the symptomatic side.

Parameter	<i>r</i>	<i>P</i> <sup>a</sup>
Pain	0.084	0.553
Lateral distal femoral angle	0.251	0.073
Medial tibial proximal angle	0.172	0.223
Q angle	0.180	0.202
Quadriceps femoris strength (60 deg/s)	-0.294	0.034
Hamstring strength (60 deg/s)	0.352	0.011

<sup>a</sup>Pearson correlation coefficient test (*P* < 0.05).

balance performance. In the present study, the severity of knee pain did not relate to OLSSB. The differences between these studies may be the result of the balance test methods. Bennell and Hinman<sup>2</sup> reported that standing balance was not significantly altered by experimentally induced acute knee pain in healthy older individuals.

Previous studies showed that quadriceps and hamstring weakness was common in PFPS.<sup>3,5,28</sup> Hassan et al<sup>14</sup> showed a relationship between bilateral postural sway and maximal voluntary quadriceps activation in patients with osteoarthritis. Single-leg standing balance has been linked to stronger quadriceps in medial knee osteoarthritis.<sup>16</sup> In the present study, the peak torque of the quadriceps (51.92%) and hamstring (63.46%) on the symptomatic side was lower, and quadriceps and hamstring strength correlated with OLSSB.

In this study, the Q angle was larger than normal, while the LDFA and MTPA were normal on the symptomatic side. There was no relationship between OLSSB and the Q angle or lower extremity alignment on the symptomatic side. Hunt et al<sup>15</sup> investigated the effect of tibial alignment surgery on single-leg standing balance in patients with knee osteoarthritis. No difference was found in standing balance following high tibial osteotomy. Standing balance is a complex process not dictated by structural factors such as alignment.

There are limitations in this study, including an age-matched healthy control population. A sample size estimate was not performed. Therefore, the lack of a significant relationship between OLSSB and knee pain, Q angle, LDFA, and MTPA may be due to insufficient numbers of study patients.

## CONCLUSIONS

OLSSB decreased on the symptomatic side in PFFS patients. A quadriceps and hamstring strengthening program may be beneficial to patients with PFFS.

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