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# Dynamic postural stability and muscle strength in patellofemoral pain: Is there a correlation?

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ABSTRACT

*Background:* Although females with patellofemoral pain (PFP) show a decrease in hip and knee muscle strength, there is a lack of studies that associates this with postural stability. The purpose of this study was to assess the dynamic postural stability and muscle strength in the hips and knees of females with and without PFP, and to verify the association between the postural stability and the muscle strength in the PFP group.

*Methods:* Two groups were tested: one with 25 PFP and one with 25 asymptomatic. Postural stability was evaluated during stepping up down tasks using a force platform to determine the center of pressure (COP) excursion and velocity. A handheld dynamometer was used to assess the muscles strength. The correlation analysis was conducted between the COP variables and the muscle strength.

*Results:* The PFP group demonstrated greater total and medial–lateral COP displacement (8887.7 ± 761.7 vs. 8129.4 ± 691.9 mm, $P < 0.001$; 32.3 ± 5.5 vs. 21.7 ± 2.7 mm, $P < 0.001$) and a higher total of medial–lateral COP velocity (22.2 ± 5.2 vs. 17.0 ± 1.6 $P = 0.001$). The PFP group showed weaknesses in all muscles ($P < 0.05$), and there was a good positive correlation between the anterior–posterior displacement and the velocity of the extensor hip muscle ($r = 0.52$, $P < 0.01$; $r = 0.55$, $P < 0.001$).

*Conclusions:* Subjects with PFP have frontal dynamic postural stability deficit and show an association between hip extensor and sagittal plane stability.



## 1. Introduction

Patellofemoral pain (PFP) is one of the most common conditions of anterior knee pain, and it affects both athletes and sedentary individuals [1,2]. The prevalence is approximately one-quarter of all knee injuries treated in orthopedic and sports medicine centers [1,3]. Individuals with PFP have demonstrated diminished hip and knee extensor strength in comparison with pain-free individuals; this is also considered to be a factor that could contribute to the development of the syndrome [4]. Based on the function of these muscles in controlling lower extremity motion, the hip and knee weaknesses could increase the femoral adduction and the medial rotation, leading to excessive knee dynamic valgus during functional activities [5,6]. These alterations and the lack of adequate joint control could lead to excessive movement in the frontal and sagittal planes, resulting in postural balance instability [7–9].

Dynamic postural balance control and stability are important requirements for mobility in functional activities [10]. The motor system is responsible for the appropriate muscle activation to perform movement, and strength impairment, especially when associated with pain, could result in deficits in postural instability [7,8,11–13]. Previous studies have demonstrated the importance of hip and knee muscle performance in terms of posture and balance and show postural impairment in the frontal and the sagittal plane after knee extensor and hip muscle fatigue [11–13].

The knee and hip muscles, especially the hip abductor, play an important role in lower limb alignment and postural stability by controlling and minimizing the medial–lateral and anterior–posterior acceleration of the body center of the mass, which keeps the center of mass above the support area during postural perturbations [14,15]. Gribble [12] observed that localized fatigue of proximal musculature has a greater influence on postural control in comparison with ankle musculature fatigue. In addition, Negahban et al. [16] reported that

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isolated knee extensor and hip abductor fatigue reduced overall anterior–posterior and medial–lateral postural stability.

Lee et al. [8] found that PFP individuals with diminished hip abductor strength have a decrease in the frontal plane of postural stability; nevertheless, the association between the decrease in hip abductor muscle strength and the deficit in dynamic postural stability remains unclear. In addition, the influence of the hip extensor, lateral rotators, and knee extensor muscle strength on sagittal plane stability have not been elicited in PFP individuals. Furthermore, dynamic exercises that improve hip and knee strength and that require adequate postural control and balance are normally used in PFP rehabilitation [17,18].

Therefore, the aims of this study were to compare the dynamic postural stability and the muscle strength in the hips and knees of females with and without PFP syndrome, and to verify the association between dynamic postural strength and muscle strength in the PFP group. We hypothesize that females with PFP will exhibit postural instability and strength deficits in comparison with the control groups. In addition, postural stability will correlate with hip and knee strength in the PFP group.

## 2. Methods

The protocol for this study was approved by the Ethics Committee on Research of the University of São Paulo State protocol 153/11.

### 2.1. Subjects

The case–control study consisted of 50 females who were divided into two groups: the PFP group ($n = 25$) with either unilateral or bilateral PFP and a control group ($n = 25$). The subjects were recruited from the University of São Paulo. The inclusion criteria for the PFP group were: a history of anterior knee pain unilateral or bilateral; pain for at least three months; the presence of pain of at least three centimeters on the numeric pain rating scale (NPRS) [19]; reported pain when performing at least three activities, including squatting, jumping, running, kneeling, standing when squatting, climbing up or down stairs, sitting for long periods, or performing resistance exercises (isometric knee extensions at 60° of knee flexion) and palpating the medial or lateral facet of the patella [20]. The inclusion criteria for the control group were no history of injury to the lower limbs and no knee pain in any of the previously described activities. The exclusion criteria for both groups were a history of knee surgery, ligamentous injuries, meniscus injuries, and patellar tendinopathy, traumatic patellar dislocation, hip or ankle injuries, neurological conditions, use of anti-inflammatory medications, pregnancy, and a body mass index above 28 kg/m$^2$.

All participants received an orientation regarding the research and signed an informed consent form approved by the Ethics Committee.

The required sample size was calculated in order to identify a difference of 20 mm of center of pressure (COP) displacement between the two groups [8]; there was an assumption of an 80% statistical power and significance level of 0.05 within a minimum of 23 subjects per group.

Thirty-nine subjects were contacted for the PFP group, and 30 females were contacted for the control group, respectively. However, only 25 participants were eligible for each group.

### 2.2. Procedures

A physical therapist with six years of experience as an orthopedic specialist conducted a physical examination on the subjects in order to verify the inclusion and exclusion criteria. The same examiner that performed the initial selection collected all the data. Anthropometric measures (age, height, and weight), pain intensity, duration of pain, and function ability during daily activities were recorded prior to testing. The subjects performed the step up and down task over a raised platform to evaluate dynamic postural control, and after 30 min of rest, they were tested for knee and hip isometric muscle strength. The affected limbs were assessed in the unilateral PFP group, and the more affected limb was assessed in subjects with bilateral pain. For the control group, the dominant limb was assessed. The dominant limb was defined by the question, “If you had to kick a ball as hard as possible, which leg would you use?”

#### 2.2.1. Postural stability evaluation

Dynamic postural balance was assessed using the force platform, NeuroCom International Balance Master®, to evaluate the center of pressure during the step up and down task. The subjects positioned their bare feet on a standard line with their arms alongside their hips, and a visual stimulus on the computer screen was the signal for the subjects to begin the step up and down task (Figure 1). They were instructed to perform the activity at a comfortable speed as they normally would during daily activities. Subjects were allowed to move their arms if necessary to maintain their balance. The step height was standardized at 20 cm and placed over the calibrated force platform [21]. All subjects performed one practice test to become familiar with the procedure and equipment. After five minutes of rest, they performed three trials with a resting time of one minute between trials.

#### 2.2.2. Strength evaluation

The Nicholas handheld dynamometer (Lafayette Instrument Company, Lafayette, IN, USA) was used to measure hip and knee isometric strength. This instrument is widely used clinically to measure muscle strength [18,22], and it has also demonstrated excellent inter-rater and intra-rater strength measurement reliability in females with PFP [23].

The strength of the knee extensor was evaluated while the subjects sat on the examination table with the hip in a 90° flexion, the knee in a 60° flexion, and their arms held against their chests [24]. The handheld dynamometer was positioned near the malleoli. For the hip abductors, the subjects were positioned in a side-lying position with the evaluated limb in a neutral position with a pillow between the legs and the dynamometer placed over the lateral femoral condyle [24]. The hip extensors and external rotators were evaluated while the subjects were in a prone position with the knee flexed at 90° and the tibia perpendicular to the examination table. The dynamometer was placed in the posterior thigh region above five the inter-articular of the knee [18,22] and one centimeter from the medial malleolus [23]. An immovable strap was used for all tests to secure the handheld dynamometer and to avoid any influence of force from the evaluator.

The muscle group test was randomized using Random Allocation Software. Before testing each muscle group, the subjects were allowed two submaximal contractions in order to become familiar with the procedure. The subjects then performed two maximum voluntary contractions for each muscle group, and we provided consistent verbal encouragement to the subjects. Each contraction was maintained for five seconds with a 30 second rest between repetitions. The rest between evaluation muscle groups was standardized to one minute.

The maximal torques were calculated as the product of each muscle segment and the isometric force measured with the handheld dynamometer [25]. The intraclass correlation coefficients (ICCs) [26] for isometric strength measures were between 0.90 and 0.97 for all muscles, which shows excellent reliability.

#### 2.2.3. Functional evaluation

Pain intensity was measured using an 11 point numeric pain rating scale (NPRS) [1] in which 0 corresponded to “no pain” and 10 corresponded to “worst pain imaginable” [17]. The function was measured using 14 items from the Knee Outcome Survey on the daily living scale. Each item is based on six points with the highest score representing no difficulty in performing the activity and with the lowest