

Original Article

Dynamic postural control during step down task in patients with patellofemoral pain syndrome

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Abstract. [Purpose] This study aimed to examine the differences in dynamic postural control during forward step down (FSD) task in patients with patellofemoral pain syndrome (PFPS). [Participants and Methods] Sixty-eight participants (34 males and 34 females) were divided into the following 2 groups: 34 PFPS patients (17 males and 17 females) and 34 healthy controls (17 males and 17 females). Each participant performed FSD task from a height of 20 cm. A force platform was used to extract the center of pressure parameters during FSD task for calculation of time to stabilization (TTS) in the anterior-posterior (A/P) and medial-lateral (M/L) direction. [Results] PFPS group took longer time to stabilize than the healthy control group in A/P and M/L directions. A main effect for direction was found, and this indicated that the A/P TTS of 8.43 ± 0.79 s was longer than the M/L TTS of 5.56 ± 1.95 s in healthy participants and A/P TTS of 9.09 ± 0.82 s was longer than the M/L TTS of 7.15 ± 2.11 s in PFPS. [Conclusion] These findings suggest that dynamic postural control can be affected in PFPS patients.

Key words: Patellofemoral pain syndrome, Time to stabilization, Step down test

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most common causes of knee pain during activities involving loading of the patellofemoral joint. It has been estimated that approximately 6–30% of the general population suffers from patellofemoral pain at some point in time in their lives and this incidence is even higher in active, athletic population¹⁾. Descending stairs is one of the major functional limitations in patients with PFPS²⁾. The load of the patellofemoral joint during stair descent has been reported to be more than 3.5 times that of their body weight³⁾. Theoretically, impaired dynamic postural control during stair descent may produce greater patellofemoral joint stress associated with subsequent knee pain in patients with PFPS. Therefore, investigating postural control while descending stairs would be useful for better understanding of the underlying problems associated with PFPS⁴⁾. The step-down test mimics the function of stair descent and is frequently used in clinical settings as a functional performance test in patients with PFPS^{3, 5)}. Loudon et al.³⁾ in a study demonstrated that step down test showed the highest reliability between 5 functional performance tests in patients with PFPS (ICC: 0.94).

Postural control is an essential component of daily and sports activities. A novel objective measure of dynamic postural control is time to stabilization (TTS)^{6–8)}. TTS is a functional examination of stability by definition, forcing participants to maintain balance through a transition from a dynamic to a static state. The measurement technique of TTS with a FSD task protocol was successfully used to assess dynamic postural control in individuals with lower extremity injuries such as anterior cruciate ligament injury and ankle instability. Although stair descent is a common aggravating factor in patients with PFPS, the TTS method during FSD task is yet to be used to investigate the dynamic postural control of this population.

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Therefore, the present research aims to use TTS to measure the differences in dynamic postural control during FSD task in PFPS patients compared with healthy participants.

PARTICIPANTS AND METHODS

A total of 68 participants (34 males and 34 females) were divided into the following 2 groups: 34 PFPS patients (17 males and 17 females; with mean age, height, and weight of 24.24 ± 2.93 years, 168.78 ± 8.89 cm, and 67.76 ± 14.6 kg, respectively) and 34 healthy controls (17 males and 17 females; with mean age, height, and weight of 23.15 ± 3.04 years, 166.50 ± 8.96 cm, and 63.55 ± 9.64 kg, respectively). Inclusion criteria for patients group included age range between 18 to 45 years, history of anterior knee pain for at least 3 months, pain ratings of 30/100 on Visual Analogue Scale, anterior knee pain or retropatellar pain on at least two of the following activities: prolonged sitting with bent knees, squatting, kneeling, running, hopping/jumping and ascending or descending stairs^{9, 10}. Patients with diagnosis other than PFPS such as knee ligament, meniscus and tendon injuries, genu varum, genu valgum, involvement of other joints affecting lower extremity or back, pronated foot, history of lower extremity surgery, systematic inflammatory rheumatic disease, neurological conditions and psychiatric disorders were excluded from the study^{4, 11}. The healthy control group should have no musculoskeletal or neurological disorders. In PFPS participants where both limbs were involved, the more symptomatic limb was considered as the involved limb. In the control group, the dominant limb was tested. Written and informed consent was provided by all participants before participation. The study protocol was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (Ahvaz, Iran) with an approval code of IR-AJUMS-REC-1394-707.

To examine the dynamic postural control during FSD task, a force platform (Kistler 9286BA, Kistler Inc., Switzerland) was used to extract the center of pressure (COP) parameters during FSD task. The COP data were sampled at 200 Hz and filtered using a 4th order butter worth low pass filter with a cut-off frequency of 10 Hz and was normalized to bodyweight¹¹. All data were analyzed using method first described by Colby et al¹². The TTS in the anterior-posterior (A/P) and medial-lateral (M/L) direction for each trial were calculated using COP data. The TTS is the time taken for a participant to return to a baseline or stable state following a FSD task. A longer TTS indicates more difficulty in controlling posture at landing and might indicate impaired neuromuscular or postural control¹³. The FSD task for detecting TTS consisted of a single landing step from a height of 20 cm onto the force platform¹⁴. The initial position of the participant was with both bare feet on the step facing the force plate. Participants were asked to place their hands on their hips while looking straight ahead. Immediately after a verbal cue, the participant stepped forward, leading with the test leg, and finally landing on the test leg only from the step on the force plate. Participants were instructed to stabilize as quickly as possible and to maintain this position until a verbal cue was given to indicate completion of the 30 second trial duration. Patients did not report any pain during the test. TTS scores were determined by sequential estimation. MATLAB software was used to calculate TTS in seconds¹². The mean of 3 trials was used for further calculations¹³.

Functional step-down which was used to evaluate performance between groups is a unilateral test performed from a platform, 8 inches (20 cm) high. Participants step forward and down toward the floor. The down limb only brushes the floor with the heel and then returns to full knee extension. This counts as one repetition. The number of repetitions performed by the participant in 30 seconds is recorded as functional step down test score. The average of three trials was used for statistical analysis³.

Data was analyzed using SPSS for Windows 22.0 (SPSS Inc., Chicago, IL, USA). Independent-samples t-tests were carried out to assess group differences in the A/P TTS, M/L TTS and step down test score. P-values less than 0.05 were considered significant.

RESULTS

From the results of this study, the PFPS group took longer time to stabilize than the healthy control group in A/P and M/L directions ($p=0.001$ and $p=0.002$, respectively). A main effect for direction was found, and indicated that the A/P TTS of 8.43 ± 0.79 s was longer than the M/L TTS of 5.56 ± 1.95 s in healthy participants and A/P TTS of 9.09 ± 0.82 s was longer than the M/L TTS of 7.15 ± 2.11 s in PFPS ($p=0.02$). **Table 1** presents the mean \pm SD associated with the A/P and M/L TTS in healthy

Table 1. Differences in dependent variables between PFPS and healthy control participants

	Healthy	PFPS
	Mean \pm SD	Mean \pm SD
A/P TTS (s)	8.43 ± 0.79	$9.09 \pm 0.82^*$
M/L TTS (s)	5.56 ± 1.95	$7.15 \pm 2.11^*$
Step down repetition	22.29 ± 2.71	20.84 ± 4.23

* $p<0.05$. A/P TTS: Antero-posterior time to stabilization; M/L TTS: Medio-lateral time to stabilization; Step down repetition: Score of functional step down test.

and PFPS participants. No difference was found in functional step down test score between healthy and PFPS participants ($p=0.096$). Results of ANOVA test showed that the main effect of group (healthy/PFPS) was significant ($p=0.001$), but main effect of gender (males/females) and interaction of gender by group was not significant ($p=0.915$ and 0.228 respectively).

DISCUSSION

Dynamic postural control is defined as the ability to maintain whole-body stability and orientation while transitioning from a dynamic to a static state¹³. Because postural control requires integration of sensory inputs and sensory inputs affect motor components such as muscle strength, muscle activation, and contraction patterns, knee pain can theoretically alter postural control independently. Anterior knee pain can interfere with proprioceptive signals at higher levels of motor control, resulting in impaired postural control during functional activities¹⁵.

A few studies have shown that patients with PFPS have altered static postural control which is measured with a force platform, in upright standing, compared to healthy controls^{16, 17}. But to the best of our knowledge, this study is the first attempt to identify dynamic postural control during stairs descent, which is a common aggravating factor in patients with PFPS. According to the present results, TTS as a measure of dynamic postural control that analyzes the time required for a participant to recover from a perturbation and to stabilize the ground reaction forces within a range similar to a stable stance phase, was longer in PFPS patients compared to healthy participants, indicating postural control impairment in PFPS patients during FSD task.

These findings are consistent with the findings in previous researches, demonstrating that longer TTS is associated with other lower extremity disorders such as anterior cruciate ligament injury and ankle instability^{12, 18–21}. Ross et al.²⁰ in a study demonstrated longer TTS in the chronic ankle instability patients than in the healthy participants. Also, Colby et al.¹² studied the effect of ACL injuries on TTS by comparing the injured and uninjured legs of those with ACLR or ACL-deficient knees compared to those with healthy knees while performing a hop test and a step-down test. In a within-participants comparison, their results demonstrated that the ACLR knees had greater vertical TTS than the uninjured knees during the step-down test.

Although the main effect for direction was not related to our research question, our significant finding indicates that the A/P TTS was longer than the M/L TTS. Nashner²² suggested that impaired postural control might result from a small base of support and decrease the limits of stability. In the present study, patients' small base of support in sagittal plane might allow the COP to approach the narrower sagittal limit of stability, which could destabilize posture and increase the stabilization time after stepping down.

However, the average score of the functional step down test in the patients group was lower than the healthy group, although this difference was not significant. This finding confirms the hypothesis that the dynamic postural control deficits obtained in this study may be a contributing factor for PFPS rather than resulting from the differences in functional or performance state between two groups. Also, the results of this study showed that functional step down test may fail to elicit postural control deficiencies in PFPS patients. Therefore, a dynamic laboratory measure such as TTS would be more challenging and potentially more effective for detecting deficits in participants with PFPS.

In conclusion, the results of this study confirm the dynamic postural control deficits during step down task in PFPS patients. Future studies should expose larger group of PFPS patients to different functional conditions and also examine different parameters of dynamic postural control in these patients.

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Conflict of interest

None.

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