LATERAL STEP-DOWN IS MORE SENSITIVE TO LOWER LIMB MISALIGNMENT IN PATIENTS WITH PREPATELLAR PAIN THAN FORWARD STEP-DOWN

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The aim of this study was to determine whether forward or lateral step-down tasks were more sensitive in detecting lower limb misalignment in individuals with patellofemoral pain syndrome (PFPS). The PFPS group (n=26) and the healthy controls group (HC) (n=20) performed the forward step-down (FSD) and the lateral step-down (LSD). Lower extremity kinematic metrics were captured by an 8-camera motion capture system. A two-way ANOVA assessed the effect of group and sex on these metrics. Results revealed that in FSD, there was only a main effect of sex. In LSD, PFPS showed greater peak hip adduction angle (p = 0.04), peak hip internal rotation angle (p = 0.01) and peak pelvic angular velocity. The lateral step-down task emerged as a more sensitive tool for quantitatively evaluating abnormal dynamic lower limb force lines in PFPS.

KEYWORDS: PFPS, forward step-down, lateral step-down.

INTRODUCTION: Patellofemoral pain syndrome (PFPS), also known as running knee, is a prevalent orthopedic condition in sports medicine. The etiology of PFPS is believed to involve abnormal lower limb mechanics. Changes in the lower limb during unilateral weight-bearing activities, such as dynamic valgus or valgus collapse (McLean et al., 2005), have been linked to an elevated risk of lower limb injury (Song et al., 2011).Diagnosing PFPS typically involves multifactorial diagnostic and imaging tests (Barton et al., 2015), which can be cumbersome and expensive. To streamline the diagnostic process, researchers have proposed integrating these tests with functional assessments (Fredericson & Yoon, 2006). Notably, special tests focusing on lower limb alignment. (Willson & Davis, 2008) or lower limb motor chain (Powers, 2010) have garnered attention. Functional tests examining the pathological characteristics of PFPS have been developed(Cook et al., 2010; Nunes et al., 2013), with the step-down test being one of the most recommended (Lopes Ferreira et al., 2019). Existing studies have predominantly concentrated on forward step-down, with a scarcity of research comparing forward and lateral step-down tasks. Therefore, the aim of this study was to determine whether forward or lateral step-down tasks were more sensitive in detecting lower limb misalignment in individuals with PFPS. We hypothesize that lateral step-down is better recognized.

METHODS: This study recruited twenty-six participants with PFPS (PFPS group) and twenty healthy control participants (HC group) (Table 1). The PFPS met specific inclusion criteria, experiencing knee pain during activities like stairs, running, jumping, for over 3 months. The control group had no history of knee injury or pain. Participants with a history of lower limb surgery and knee joint dysfunctions were excluded from both groups. Twenty-six reflective markers were placed on the anterior superior iliac spines, posterior superior iliac spines, anterior thighs, medial femoral condyles, lateral femoral condyles, tibial tuberosities, anterior superior shanks, medial malleolus of tibias, lateral malleolus of fibulas, heels, and metatarsophalangeal joints. A 3D kinematic analysis of the pelvis and lower limbs was undertaken using an 8-cameras motion capture system (Qualisys Aqurs12, Sweden, 200Hz).

Table 1. Demographic data of the control and patellofemoral pain groups.

	PFPS（n=26）		HC（n=20）	
	Male（n=17）	Female（n=9）	Male（n=10）	Female（n=10）
Age, years	22.9 ± 2.2	23.2 ± 4.7	22.8± 2.2	22.6±2.3
Height, m	1.77 ± 0.5	1.64 ± 0.5*	1.78±0.6*	1.63±0.6
Mass, kg	67.4 ± 6.0	58.0 ± 7.6*	69.2±5.8*	56.5±7.5
Years of running training, years	3.8 ± 2.1	3.6 ± 2.0	3.7±2.9	3.7±2.5
Anterior knee pain scale, 0-100	83.0 ± 7.8	85.9 ± 5.2	—	—
Involved limb, right/left	4/13	5/4	—	—

#Significant difference between PFPS group and HC group (p<0.05); *Significant difference between males and females (p<0.05); the same as below.

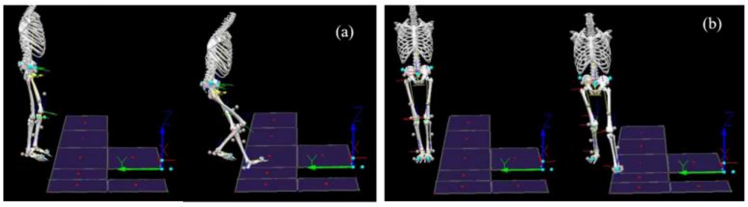

Figure 1. Forward step-down(a) and lateral step-down(b).

Participants stood on the edge of a 20-cm high box, and bending their supported leg until the contralateral heel touched the ground (Figure 1). In the FSD, their toes were aligned with the outer edge of the box. In the LSD, the medial edge of the supported leg was aligned with the lateral edge of the box. For the PFPS group, evaluation focused on the painful lower limb, selecting the limb with the highest pain level on the anterior knee pain scale in cases of bilateral symptoms. For the HC group, the average of both lower limbs presented the healthy side.
Reflective markers were tracked using Qualisys Track Manager software and processed in Visual3D (C-motion, USA). Marker trajectories were filtered using a fourth-order Butterworth filter with a cut-off frequency of 13.3 Hz (Yu et al., 1999). Descriptive statistics were used to summarize the characteristics of the participants and the measurements. The normality of the data was assessed with Shapiro-Wilk tests. A two-way ANOVA was conducted to analyze the effects of group and sex on the variables of interest. In cases where PFPS-by-sex interactions were present, student’s t-tests were conducted to determine the effect of two independent factors on the results. Results are presented as mean± SD with a significance level of 0.05. Statistical analysis conducted using R4.3.0 software.

RESULTS: In the FSD, there was no PFPS-by-sex interaction for any variables. However, a main effect of sex was observed for peak knee abduction angular velocity, with males showing greater values than females ($p < .05$, $\eta^2 = .09$). In the LSD, there was no PFPS-by-sex interaction for pelvic and hip metrics. But there was an interaction for knee abduction angle ($p = .04$, $\eta^2 = .11$), where males in the HC group had greater values than in the PFPS group ($t = -3.03$, $p = .01$). The PFPS showed significant main effects, with greater hip adduction angle ($p = .04$, $\eta^2 = .11$) and hip internal rotation angle ($p = .01$, $\eta^2 = .16$) compared to the HC group. For peak angular velocities, there was a significant PFPS main effect for contralateral pelvic drop velocity (p = .01, η^2 = .18) and pelvic rotational angular velocity (p = .02, η^2 = .14), with higher values in the PFPS group. A main effect of sex was observed for knee adduction angular velocity, with males showing greater values than females (p = .03, η^2 = .13) (Table 2, Table 3).

Table 2. Peak joint angles in FSD and LSD (°, Mean ± SD).

	Peak joint angles	PFPS		HC		HC (n=20)	PFPS (n=26)	Male (n=27)	Female (n=19)
		Male (n=17)	Female (n=9)	Male (n=10)	Female (n=10)				
FSD	Contralateral pelvic drop	4.5±1.3	4.4±2.4	5.4±1.9	5.5±1.2	5.5±1.6	4.5±1.7	4.9±1.6	4.9±2.0
	Pelvic rotation	3.1±2.4	2.7±4.5	2.5±2.6	1.5±2.0	2.0±2.3	3.0±3.2	2.9±2.4	2.1±3.4
	Hip adduction	13.2±4.8	12.3±3.7	11.0±4.8	11.9±4.5	11.4±4.5	12.9±4.4	12.4±4.8	12.1±4.0
	Hip internal rotation	9.0±5.7	4.2±7.2	4.5±6.0	5.2±5.0	4.8±5.4	7.3±6.5	7.4±6.1	4.7±6.1
	Knee abduction	1.0±2.4	-1.9±4.2	-1.5±1.6	-0.9±4.2	-1.2±3.0	0.1±3.3	0.2±2.4	-1.4±4.1
LSD	Contralateral pelvic drop	6.8±2.0	5.9±2.0	6.9±1.8	6.9±3.1	6.9±2.2	6.5±2.0	6.9±1.9	6.3±2.4
	Pelvic rotation	7.7±4.8	10.1±6.1	5.8±2.8	9.1±3.5	6.9±3.4	8.7±5.4	6.8±4.1	9.7±5.1
	Hip adduction	11.0±3.9	11.4±4.8	8.7±3.8	7.9±3.7	8.4±3.7**#**	11.2±4.2	10.0±3.9	10.0±4.6
	Hip internal rotation	10.6±4.4	6.7±5.1	4.0±6.1	5.4±6.7	4.5±6.2**#**	9.0±5.0	7.6±6.1	6.1±5.6
	Knee abduction	1.2±2.4**#**	-1.7±4.6	-1.8±2.3	-0.4±3.0	-1.2±2.7	0.0±3.7	-0.1±2.8	-1.1±3.9

Table 3. Peak joint angular velocity in FSD and LSD (°/s, Mean ± SD).

	Peak joint angular velocity	PFPS		HC		HC (n=20)	PFPS (n=26)	Male (n=27)	Female (n=19)
		Male (n=17)	Female (n=9)	Male (n=10)	Female (n=10)				
FSD	Contralateral pelvic drop	16.7±5.6	21.3±11.0	16.1±3.3	14.9±4.9	15.5±4.1	18.3±8.0	16.5±4.9	18.1±8.9
	Pelvic rotation	16.8±5.5	20.2±14.7	15.5±4.7	16.2±3.9	15.9±4.2	18.0±9.6	16.3±5.2	18.2±10.6
	Hip adduction	30.8±16.8	25.0±12.7	26.4±10.4	26.4±10.0	26.4±9.9	28.7±15.5	29.2±14.8	25.7±11.1
	Hip internal rotation	56.8±16.0	55.4±22.9	58.5±12.3	53.8±7.9	56.1±10.3	56.3±18.2	57.4±14.6	54.6±16.6
	Knee abduction	57.6±41.2	32.6±17.6	37.0±17.7	32.0±10.5	34.6±14.6	49.3±36.8	50.2±35.7*	32.3±14.0
LSD	Contralateral pelvic drop	16.1±6.0	13.5±3.9	12.2±4.6	8.5±1.8	10.9±4.2**#**	15.0±5.3	14.3±5.7	11.5±4.0
	Pelvic rotation	22.5±8.7	21.6±11.8	16.1±2.3	15.7±5.9	15.9±3.7**#**	22.1±9.8	19.6±7.2	19.2±10.0
	Hip adduction	31.5±20.2	28.9±13.2	26.3±7.2	25.1±6.1	25.9±6.6	30.4±17.3	29.1±15.5	27.4±10.8
	Hip internal rotation	50.2±23.0	50.3±14.5	59.1±14.1	48.3±5.0	55.4±12.7	50.2±19.6	54.3±19.6	49.5±11.4
	Knee abduction	47.8±23.1	31.3±10.6	38.7±15.4	31.1±11.3	35.3±13.9	41.0±20.4	43.8±20.2*	31.2±10.6

DISCUSSION: Regarding pelvic movement, no PFPS abnormalities were found in the FSD, and in the LSD, the PFPS group showed greater changes in the angular velocities of the pelvis, suggesting faster pelvic motion and poorer movement control. Regarding hip movement, PFPS group showed greater peak hip adduction and internal rotation angles in the LSD, consistent with previous stairs studies (de Oliveira Silva et al., 2016). In terms of knee movement, the PFPS group have a smaller knee abduction angle than the HC group in the LSD, possibly related to the pain avoidance mechanism (Hodges & Tucker, 2011).From our results, more sex differences were mainly shown in the FSD task, while more PFPS differences were shown in the LSD. In terms of movement patterns, differences in the tendency of the contralateral limb to move make the final movement results different (Lopes Ferreira et al., 2019). The PFPS showed more pelvic and hip differences when performing the LSD task, with LSD requiring more control of pelvic and hip movements than FSD.

CONCLUSION: Compared to the forward step-down, the lateral step-down is more sensitive to lower limb malalignment in patients with prepatellar pain. It also becomes a more sensitive and useful tool for clinicians to use.

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