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Descending stairs: Good or bad task to discriminate women with patellofemoral pain?

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ABSTRACT

Background: There is no consensus on kinematics alterations during descending stairs in females with patellofemoral pain (PFP). In addition, there are no studies that have evaluated the three dimensional kinematics of the trunk, pelvis, hip, knee, and ankle using a multi-segmental model of the foot simultaneously during this task in patients with PFP and evaluated the subphases of stair descent. The objectives of this study were to compare the three dimensional kinematics of the trunk, pelvis, and lower limbs during different subphases of stair descent and identify the discriminatory capacity of the kinematic variables among women with PFP and healthy women.
Methods: In this cross-sectional study, thirty-four women with PFP and thirty-four pain free women between 18 and 35 years-old were submitted to three-dimensional kinematic evaluation during stair descent.
Results: It was observed that kinematic differences between the groups occurred in the first double support phase of the stair descent, with the variables of internal rotation of the hindfoot in relation to the tibia in the initial contact (2.1°; sensitivity = 68.6%, specificity = 61.8%) and contralateral pelvic drop in load response (1.3°, sensitivity = 65.7%, specificity = 63.7%) presenting the best ability to discriminate women with and without PFP.
Conclusion: Our results suggest that kinematic changes during stair descent should be used with caution during the evaluation and decision-making process in women with PFP.

1. Introduction

The etiology of PFP is multifactorial [1] and an often accepted hypothesis is excessive stress at the patellofemoral joint, which may result from poor alignment of the lower limbs during closed kinetic chain activities that increases compressive forces at the joint, overloading the cartilage and leading to an increase in pressure in the subchondral bone, which consequently causes symptoms of pain in the patient [2–4]. The biomechanical alterations observed in individuals with PFP can be divided into proximal, local, and distal factors [5,6]. The proximal factors consist of muscle weakness [7–9] and/or deficits in hip muscles activation [8,10], contributing to excessive hip adduction and internal rotation in closed kinetic chain activities. Local factors are related to weakness [11], hypotrophy [12], and deficit in quadriceps activation 10,13,14] as well as reduction in knee flexion [15] and reduction in the peak knee extensor moment [16] as a compensatory mechanism to reduce compression at the patellofemoral joint. Studies related to distal factors, which have received the least attention from researchers to date, suggest that excessive pronation of the subtalar joint during the stance phase of gait may result in an increase in internal tibial rotation due to the coupling of the talus at the ankle joint, and consequently in the internal rotation and adduction of the femur, which could contribute to the PFP etiology [2,17].

Descending stairs is a functional activity commonly found in activities of daily living and normally reproduces symptoms in patients with PFP, and for this reason, may reveal abnormal movement patterns [16,18].

Evidence found in the literature is inconsistent and there is no consensus on the movements performed by women with PFP during stair descent. Considering that the distal segment may also present

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biomechanical alterations that contribute to the development of PFP, studies that have evaluated kinematics through a multi-segmental model of the foot, and their relevance during stair descent remain unknown. Furthermore, to our knowledge, there are no studies that have evaluated the three dimensional kinematics of the trunk, pelvis, hip, knee, and ankle, associated with a multi-segmental model of the foot, in order to simultaneously identify the proximal, local, and distal alterations during stair descent, and separately evaluated the first double support, single support, and second double support subphases.

Therefore, the objectives of this study were: 1. To compare and identify kinematic differences in the trunk, pelvis, hip, knee, ankle, and foot between women with PFP and asymptomatic women in different subphases of stair descent; 2. To identify the discriminatory capacity of kinematic variables that present intermediate and large effect sizes between women with PFP and healthy women during stair descent.

2. Methods

2.1. Participants

In this cross-sectional study, 34 women with patellofemoral pain (PFP group) and 34 pain free women in the control group (CG), all physically active and aged between 18 and 35 years, were recruited from the local community and university students, between August/2015 and March/2016. The demographic data of the participants are shown in Table 1.

This study was approved by the Local Ethics and Research Committee and all participants were informed about the procedures of the study and signed the Informed Consent Term.

The inclusion criteria for the PFP group were the presence of anterior knee pain with a minimum intensity of 3 on the Numerical Pain Ratio Scale (NPRS) for a minimum period of 6 months during at least two of the following activities: prolonged sitting, ascending or descending stairs, squatting, running, or jumping [19,20]. For the CG, women without a previous history of anterior knee pain were included. Were excluded for both groups women with a history of lower limb surgery, recurrent patellar dislocation or chronic instability, dysfunctions associated with the knee joint such as meniscal and/or ligament injuries, and cardiac or locomotor disorders that could influence assessment and treatment, as well as women who presented a limb length discrepancy greater than 1 cm, measured with a tape measure.

2.2. Procedures

Participants from both groups initially completed an evaluation form with personal data, and for the PFP group, the duration of symptoms and predominant side of pain. Subsequently, the volunteers were submitted to the protocol of anthropometric measurements necessary for the accomplishment of the three-dimensional kinematic evaluation through the concomitant application of the biomechanical models Vicon® Plug-in-Gait and Oxford Foot Model®, composed of: height, weight, distance between the anterior superior iliac spines, lower limb length, knee width, ankle width, and tibial torsion measurement using a goniometer.

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

	Control Group (n = 34)	PFP Group (n = 34)	P value
Age (years)	26 (23 - 28)*	23 (20 - 31)*	0.712
Body mass (kg)	55 (51 - 61)*	58 (52 - 62)*	0.369
Height (m)	1.61 (1.60 -1.70)*	1.60 (1.55 - 1.65)*	0.019
BMI (kg/m^2)	20,5 (19 - 23)*	22,4 (20 - 24)*	0.050
Length lower limb (cm)	852 (825 – 876)*	835 (798 - 870)*	0.099
FPI (-12 – +12)	5.0 (3 - 6)*	7.0 (5 - 8)*	0.003
NPRS (0 -10)	0	6.5 (5 - 7.25)*	–
AKPS (0 – 100)	100	67.35 ± 9.33**	–
Speed (m/s)	0.8 (0.74 – 0.85)*	0.7 (0.67 – 0.79)	0.002
Cadence (steps/min)	69.6 (66.7 – 75.8)*	65.1 (58.3 – 75.05)	0.035

*Data expressed as median (interquartile interval) ** Data expressed as mean ± SD. Abbreviations: BMI = body mass index; FPI = Foot Posture Index; NPRS = Numerical Pain Rating Scale; AKPS = Anterior Knee Pain Scale.

In order to identify the static posture of the feet, the Foot Posture Index (FPI) was applied [21]. Studies indicate that the clinical measurement of the Foot Posture Index presents moderate to high reliability in evaluating the adult population [22].

Participants in the PFP group answered to the Anterior Knee Pain Scale- AKPS [23], and reported the intensity of their knee pain through the Numerical Pain Rating Scale – NPRS [23], based on the seven days prior to the exam.

2.3. Kinematic analysis

For the three-dimensional kinematic analysis of the trunk, pelvis, and lower limbs, the Vicon® system was used, consisting of 8 cameras at a frequency of 120 Hz. Based on the biomechanical models Vicon *Plug-in Gait*® and *Oxford Foot Model*® 49 retro-reflective spherical markers of 9 and 14 mm diameter were fixed with double-sided tape (3M®) at specific anatomical points, which served as a reference for the movement analysis capture system (Fig. 1). Alignment of foot markers was determined using a laser [24].

Four trials of stair descent were performed, with an interval of two minutes between attempts. Prior to the descent, the examiner demonstrated the task and provided verbal instructions related to the test, after which the participants were allowed three trial attempts to familiarize themselves and descend without the use of a handrail. In the PFP group, the painful lower limb was evaluated, and in the presence of bilateral symptoms, the lower limb with the highest pain level on the NPRS scale was selected for the analysis, while in the control group the dominant lower limb was assessed.

For the accomplishment of the task a stair with three steps, 200 mm high and 300 mm deep each was used. Participants performed the tasks barefoot, and at a comfortable self-selected speed. Initially, a pilot study was performed with 5 asymptomatic individuals and 5 women with PFP in order to evaluate the reproducibility of the test, and the values of the standard error of measurement (SEM) involving all the evaluated segments were between (0.97° – 3.32°).

2.4. Data processing

The Vicon® *Plug-in-Gait* and *Oxford Foot Model*® biomechanical models were then applied simultaneously using Vicon Nexus® 2.5 software and saved in C3D format.

After reconstruction of the biomechanical model, the movement cycle was defined, starting with the touch of the evaluated foot on the second step of the stair and finishing with the touch of the same foot on the ground. The kinematic data were filtered using a fourth-order zero-lag Butterworth 8-Hz low-pass filter. A specific routine was developed in Vicon ProCalc® software in which it was possible to extract and calculate the variables of interest for the statistical analysis.

The stance phase was divided into first double support, single support, and second double support subphases. In the first double support, the angular data at initial contact, load response, and the range of motion (ROM) and the minimum, maximum and ROM values were extracted during single and double support (Fig. 2).

2.5. Statistical analysis

The independent T-test and the independent Mann-Whitney test were used to compare the demographic data. To compare the kinematic data between the two groups the mean of the trials was used for the