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Knee kinetic pattern during gait and anterior knee pain before and after rehabilitation in patients with patellofemoral pain syndrome

B. Claudon [a], M. Poussel [b], C. Billon-Grumillier [a], C. Beyaert [a,b,*], J. Paysant [a]

[a] Laboratoire d'analyse du mouvement, Institut Régional de Réadaptation de Nancy, Centre de Réadaptation Louis Pierquin, 54000 Nancy, France
[b] EA3450, Laboratoire de Physiologie, Faculté de Médecine de Nancy, avenue de la Forêt de Haye, 54500 Vandoeuvre-les-Nancy, France

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ABSTRACT

Patellofemoral pain is likely due to compressive force acting on the patella related in turn to knee extension moment. The latter variable was assumed to be (i) reduced during short-distance free walking in case of patellofemoral pain syndrome and (ii) increased after therapeutic pain reduction. Peak knee extension moment at beginning of stance phase was recorded by three-dimensional gait analysis in 22 controls and in 23 patients with patellofemoral pain syndrome before and after rehabilitation of knee extensors and flexors to reduce the pain. Pain would occur mainly in stressful activities such as stair negotiation or squatting and was quantified by the anterior knee pain scale. Peak knee extension moment was significantly reduced in all the patients before treatment ($n = 23$) compared to controls, although no one had pain during free walking. In the 17 patients who experienced significant post-rehabilitation pain reduction in their stressful activities, the peak knee extension moment was significantly reduced before treatment compared to controls and significantly increased after treatment, reaching values similar to control values. The peak knee extension moment during free walking appears to be a good kinetic variable related to a compensatory mechanism limiting or avoiding anterior knee pain and may be of interest in assessing knee dynamics alteration in patients with PFPS.

1. Introduction

Patellofemoral pain syndrome (PFPS) is one of the most common causes of knee pain in athletes and non-athletes [1]. It can be defined as anterior knee pain involving the patella and retinaculum that excludes other intraarticular and peripatellar pathology [2]. Typical symptoms include pain behind and around the patella that occurs or is increased with running and activities that involve knee flexion and load the lower limbs. Several factors may create a predisposition for the development of PFPS via alterations in patellar tracking, increased patellofemoral joint forces, or combinations of these biomechanical features [2]. The most accepted hypothesis regarding the cause of patellofemoral pain is related to elevated patellofemoral joint (PFJ) reaction forces that lead to abnormal joint stress and subsequent articular cartilage wear [3–5]. The PFJ is typically modelled as a pulley system where the compressive force acting on the patella is created by the forces in the quadriceps tendon and the patellar ligament [6]. In activities that involve knee flexion and load the lower limbs, the PFJ reaction force value in sagittal plane is positively related to the internal knee extension moment (KEM) value [5,7,8]. Salsich et al. found in subjects with PFPS during stair ascent and descent that the peak KEM was reduced compared to controls [9] and was increased after patellar taping along with pain decrease [10]. The authors suggested the peak KEM reduction as a compensatory gait strategy to minimize pain and PFJ reaction force. During short-distance free level walking the PFJ is usually not painful [2,5] but knee joint dynamic alteration may occur. Nadeau et al. [11] found that subjects with PFPS compared to controls had significantly reduced peak knee flexion but non-significant reduced peak KEM at the beginning of the stance phase during level walking. A small sample size (5 subjects in each group) may have contributed to this latter result. Although short-distance free level walking is usually not painful in subjects with PFPS, a peak KEM reduction may occur as a compensatory mechanism to avoid pain. To further investigate this assumption hypothesis the purpose of this study was (1) to confirm a reduced peak KEM during level walking in subjects with PFPS compared to controls and (2) to show an increase in peak KEM associated to post-rehabilitation pain reduction.

2. Methods

2.1. Subjects

Patients with PFPS were recruited from the Pierquin Rehabilitation Center in Nancy from September 2009 to August 2010. They were screened to rule out internal derangement or patellar tendinosis (pain at tendon's palpation) and were

* Corresponding author at: Laboratoire d'analyse du mouvement, Institut Régional de Réadaptation de Nancy, Centre de Réadaptation Louis Pierquin, 54000 Nancy, France. Tel.: +33 383 683 744; fax: +33 383 683 739.
E-mail address: christian.beyaert@medecine.uhp-nancy.fr (C. Beyaert).

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Table 1
Population characteristics.

	PFPS patients ($n=23$)	Controls ($n=22$)
Gender (female/male)	12/11	12/10
Age (years)	32.5 (15.3)	24.9 (6.5)
Height (m)	1.72 (0.05)	1.73 (0.10)
Leg length (m)	0.89 (0.04)	0.91 (0.06)
Body mass (kg)	75.6 (12.9)*	66.4 (9.7)
Body mass index (kg/m^2)	25.6 (4.6)*	22.2 (2.4)
Sport BQ subscale	2.40 (2.07)	2.71 (0.94)
Non-sports leisure BQ subscale	2.61 (0.44)	2.46 (0.45)

Variables as mean (one standard deviation), BQ: modified Baecke questionnaire.
* $p < 0.05$ compared to controls.

excluded in case of knee surgery or any neurological involvement that would influence gait. The inclusion criteria were (1) pain originating specifically from the patellofemoral articulation as assessed during patellar manipulation and (2) reproducible pain with at least two of the following functional activities associated with PFPS: (a) Stair ascent or descent, (b) squatting, (c) kneeling, (d) prolonged sitting, (e) isometric quadriceps contraction [12]. Subjects in the comparison group were recruited from students and staff with the following exclusion criteria: knee pathology or trauma, knee pain, any orthopaedic or neurologic abnormalities that would influence gait. Prior to participation, all subjects gave their informed consent to take part to the study. The study was approved by the District Institutional Ethical Board.

To describe the physical activities of the analysed populations, the subjects were questioned to assess the sport and non-sports leisure subscales of the modified Baecke questionnaire [13]. The characteristics of the study populations are described in Table 1.

2.2. Experimental protocol

The patients with PFPS took part to two sessions (T0 and T1) and control subjects to one session including physical examination and three-dimensional gait analysis. A 5- to 8-week rehabilitation program to cure the pain symptoms was proposed to the patients with PFPS between T0 and T1. The rehabilitation program mainly consisted in lengthening and/or strengthening the knee extensors and/or flexors according to their contracture status and their strength performance measured by isokinetic dynamometry [2,14]. The knee extensors and/or flexors were strengthened to improve any strength deficit and to reach a isokinetic flexors:extensors maximal torque ratio of about 66%. The characteristics of knee pain were scored using the Anterior Knee Pain Scale (AKPS) [15,16]. This questionnaire mainly scores the occurrence of pain in various functional activities including stair ascent or descent, squatting, prolonged sitting, carrying a load, walking, running according to their duration or intensity. A minimum increase of 10 (out of 100) points in AKPS between T0 and T1 was considered a significant improvement in pain [15].

An optoelectronic device (Vicon Nexus, Vicon Motion Systems Limited, Oxford, UK, sampling rate of 100 Hz) and three force platforms (Advanced Medical Technology Inc.,Watertown, MA, USA, sampling rate of 1000 Hz) were used to

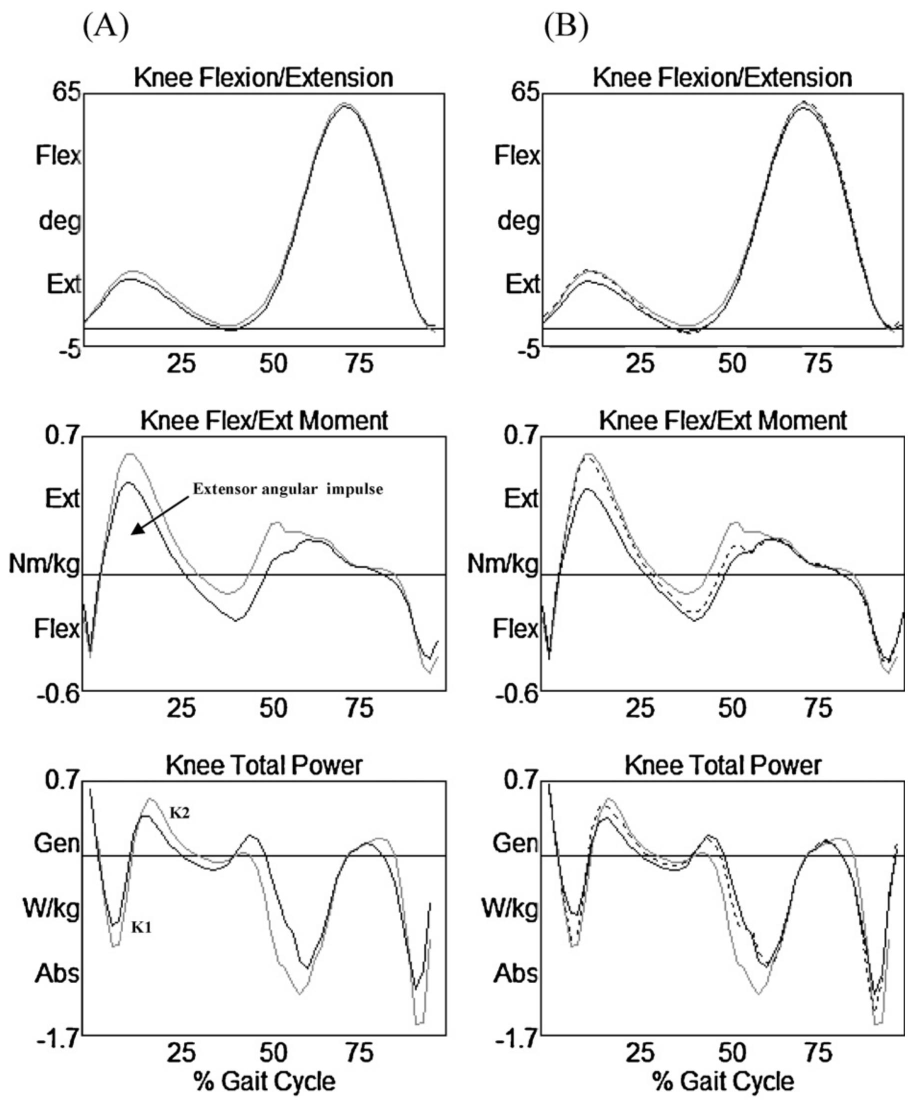

Fig. 1. Mean knee kinematics and kinetics in the patients with PFPS (black lines, all the patients (n = 23, column A) and the patients who experienced post-rehabilitation pain reduction (n = 17, column B)) and in the control group (n = 22, grey lines). Recordings at T0 (before treatment) are depicted by solid lines and at T1 (after treatment) by dotted lines. Extensor angular impulse, K1 and K2: see comments in text.