Comparison of lower extremity three-dimensional kinematics in recreational runners with and without patellofemoral pain syndrome

1Tyler Cuddeford and 2John Yack
1Nike Sport Research Lab, Nike, Inc. Beaverton OR, USA
2Physical Therapy Graduate Program, University of Iowa, Iowa City IA, USA

Introduction

Nearly 30 million Americans run for exercise, recreation or competition (Gellman et al. 1996). Given the number of strides for the average recreational runner each year is in excess of one million, any biomechanical abnormality may predispose a runner to injury. Epidemiological studies report an incidence of running-related injuries between 35-85% over a 12-18 month period, with the knee being the most frequent anatomical site of injury (Bovens et al. 1989). Patellofemoral pain syndrome (PFPS) is the most common sports-related musculoskeletal injury to the knee (Clement et al. 1981), with internal and external tibiofemoral rotation greatly influencing patellar kinematics (McClay 1990, van Kampen and Huiskes 1990). However, due to the problems associated with tracking the thigh, the biomechanical etiology of the most frequently reported running-related injury has not been uncovered (Nigg et al. 1998). Bone pin studies report RMS errors in rotation (comparing a bone pin with conventional skin-mounted markers) as high as 117%, thus making it difficult to accurately report knee kinematics using conventional skin-mounted markers. However, with the development of a new femoral tracking device, it is now possible to measure three-dimensional knee kinematics during running with accuracy between 1-3 degrees making it possible to accurately assess knee mechanics (Yack et al. 2000).

Methods

A total of 36 runners (18 with and without PFPS) participated in this study. All subjects with PFPS reported having anterior knee pain with at least two of the following activities: prolonged sitting, ascending/descending stairs, squatting, or running. In addition, runners with PFPS frequently complained of anterior knee pain following a longer-than-normal run or a run in which their running pace was faster than their regular training pace. Therefore, these runners were asked to go for a challenging run following the initial data collection and were subsequently tested after their run. Runners without PFPS were free of injury. This study utilized a four-segment rigid body model of the lower extremity including the foot, leg, thigh, and pelvis to estimate joint displacement. Three infrared light emitting diodes (IRED) defined each segment. Runners jogged at 5 mph along a 16-meter runway, speed was controlled with the use of an overhead tracking system. Five successful trials were collected. A successful trial was defined as having their speed constant, and the entire right foot striking the force platform with visually targeting. An Optotrak motion analysis system tracked the IREDS and a Joint Coordinate System was used to calculate three-dimensional angles. Three-dimensional kinematics were collected at 180 Hz and filtered using a 4th-order Butterworth, zero-lag low-pass filter with a cutoff frequency of 7 Hz. The appropriate cutoff frequency was determined using a residual analysis procedure (Winter, 1990).
Results

Runners with PFPS demonstrated significant (p<0.05) kinematic differences in internal tibial rotation (tibia relative to the foot) while jogging at 5 mph. The runners with PFPS averaged 12.8 degrees of peak tibial internal rotation while runners without PFPS averaged 8.7 degrees (Figure 1). There was no difference in the amount of tibiofemoral (tibia wrt femur) internal rotation between the two groups while running at 5 mph (Figure 2). Interestingly, following a challenging run, runners with PFPS demonstrated greater internal knee rotation compared with their initial run (Figure 3). Runners without PFPS demonstrated no difference in knee rotation following a challenging run.

**Figure 1.** Internal tibial rotation in runners with and without PFPS

**Figure 2.** Internal knee rotation in runners with and without PFPS

**Figure 3.** Change in knee rotation in runners with PFPS following a challenging run
**Discussion**

Either excessive internal rotation or excessive external rotation (of the tibiofemoral joint) may place greater stress on the patellofemoral joint (van Kampen and Huiskes 1990). The increases in peak tibial internal rotation as well as the increased range of motion of the tibia, and the increased knee internal rotation may predispose runners to PFPS by altering patellar alignment. As the femur excessively rotates on the tibia, patellar alignment is altered potentially placing increased stress onto the patellofemoral joint. Interestingly, the increased tibial rotation found in runners with PFPS was not related to an increase in subtalar joint pronation as much of the literature continues to hypothesize. Although no differences were found in knee kinematics between the groups at the beginning of a run, following a challenging run, differences at the knee did exist. It appears that runners with PFPS may lose the ability to control their knee secondary to fatigue.

**References**


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