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Patellofemoral Pain in Female Ballet Dancers: Correlation With Iliotibial Band Tightness and Tibial External Rotation

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Review of the literature reveals that ballet dancers have a high incidence of idiopathic patellofemoral pain. Twenty-four female ballet dancers were subjects in a study of the relationship between: 1) iliotibial band (ITB) tightness and patellofemoral pain, and 2) ITB tightness and degrees of tibial external rotation used in the dance demi-plie. Dancers were initially assessed by questionnaire to determine if any had knee pain. Twelve subjects met the study criteria for patellofemoral pain, and 12 dancers without knee pain served as controls for the study. Iliotibial band tightness was measured (Ober test), and degrees of tibial external rotation used during knee flexion (demi-plie) in standing were measured in both legs of all 24 subjects (48 legs). Chi-square analysis of the collected data revealed that there was an association between ITB tightness and patellofemoral pain in the dancers. Data analysis using the Wilcoxon Rank Sum test revealed that the degree of tibial external rotation used by dancers with iliotibial band tightness was significantly greater than those without ITB tightness. This study confirms the assumption that ITB tightness in dancers may be a contributing factor to patellofemoral pain. Follow-up study is indicated to determine if the preservation or restoration of functional ITB length is effective in the prevention and/or treatment of patellofemoral pain in ballet dancers.

Key Words: *patellofemoral pain, iliotibial band, ballet dancer*

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Iliotibial band (ITB) tightness has been identified as a mechanism that contributes to abnormal patellar alignment and tracking (2,3,4,6,8,10,12,16). The ITB at its proximal end originates from the fascia of the gluteus medius and the tensor fascia lata. At its distal end, the ITB sends slips to the patella which merge with the lateral retinaculum at the knee. Adaptive shortening of these structures will result in ITB tightness and interfere with normal patellar tracking (11,16).

For the ballet dancer, extreme degrees of hip external rotation and abduction are required to perform dance steps, such as the demi-plie. Performance of the demi-plie requires closed-chain knee flexion with hips in abduction and external rotation (Figure 1B) (5). Some dancers appear to compensate for insufficient external rotation at the hips by twisting the knees outwardly while bending. This maneuver alters the normal mechanics at the patellofemoral joint. When performing a deep knee bend, the ITB is pulled posteriorly over the lateral femoral epicondyle. This promotes lateral patellar deviation and encourages tibial external rotation (4,14). Damage to the inert and contractile tissues allied with the knee joint may result and set the stage for creation of anterior knee pain.

The purpose of this study was to assess the relationship between ITB tightness and patellofemoral pain in ballet dancers and to determine whether dancers with tight ITBs exhibit greater tibial external rotation during demi-plie than those without ITB tightness.

METHODS

Subjects

Forty-one female ballet dancers from a university department of dance completed questionnaires to determine if they experienced pain in front of or under the knee cap: *1*) associated with kneeling, *2*) associated with squatting, *3*) during stair climbing, *4*) associated with sensations of cracking/grinding in the knee, or *5*) associated with incidents of knee joint locking or "catching." Subjects who answered positively to three out of the five conditions were classed as having patellofemoral pain. A clinical orthopaedic examination was performed by one of the investigators on the symptomatic dancers to rule out ligamentous laxity and meniscus pathology and to assess the patellofemoral joint. Twelve symptomatic dancers were found to meet the criteria for patellofemoral pain without other knee pathology, and

For the ballet dancer, extreme degrees of hip external rotation and abduction are required.

two of these dancers had bilateral knee pain.

Twelve ballet dancers without knee pain who responded to the questionnaire consented to be in the study control group. All 24 study participants (48 knees) danced a minimum of 4 hours per week during the period of the study and all were rated as being at an intermediate or advanced skill level. Subjects signed a consent form prior to participation in the study and the research was approved by the University Human Subjects Research Committee.

Procedure

Both legs of each subject were examined for ITB tightness by one of the investigators using the Ober test (Figure 2). The test was recorded as positive if the abducted-extended hip (with knee flexed) could not be passively adducted beyond the midline of the subject's body.

Ten dancers were randomly selected to measure the degree of foot turn-out in first position (Figure 1A). Turn-out was determined by drawing and measuring on paper the angle

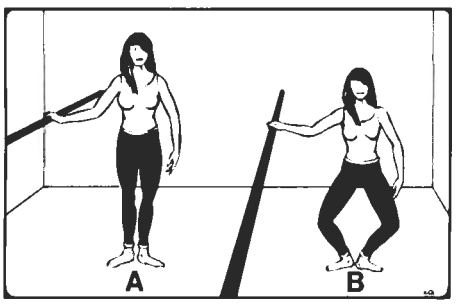

FIGURE 1. *A) Turn-out in first position. B) Demi-plie.*

FIGURE 2. *The Ober test.*

between the frontal plane and a longitudinal line running through the dancer's foot (from midcalcaneus through the second metatarsal). The average degree of foot turn-out in first position was calculated to be 25° with a standard deviation of 1.55°.

The degree of knee flexion during a demi-plie in first position (Figure 1B) was measured on the 10 selected dancers using standard goniometric procedure for knee flexion. Mean knee flexion was 30° with a standard deviation of 2.14°.

Degree of external rotation of the tibia in first position (Figure 3A) and during demi-plie (Figure 3B) was measured for both legs in all subjects. Subjects were instructed to stand on premarked recording paper in 25° of turn-out and perform a demi-plie with 30° of knee flexion (confirmed by goniometric measurement). While in this position, the examiner marked, respectively, two points on the recording paper which matched a vertical plumbline dropped first from the dancer's medial malleolus and then from the lateral malleolus of the leg. To calculate the degrees of external rotation for each leg, the recorded bimalleolar points were connected and the drawn bimalleolar axis relative to the frontal plane was measured from the paper line drawings with a protractor. Two study examiners were required to take the plumbline measurements—one dropped the plumbline and the second examiner marked it on the paper. Two measures were taken for each of the dancers in order to determine intrarater reliability. The plumbline measure of tibial external rotation was created by the examiners for this study since review of the literature revealed no previously defined method for measuring external rotation of the tibia in the test position.

Data Analysis

Tibial external rotation measurements and foot turn-out measurements were subjected to intraclass correlation coefficient (ICC) analysis to determine intrarater reliability. The association between ITB tightness and patellofemoral pain was analyzed using chi-square. The Wilcoxon Rank Sum test for two independent samples was used to analyze differences between tibial external rotation in dancers with and without ITB tightness. This nonparametric test was chosen because there was not a normal distribution within the samples and sample size was greater than 10.

RESULTS

The ICC value for intrarater reliability was .97 for measurement of tibial external rotation in first position turn-out. The ICC value for intrarater reliability was .94 for measures of external tibial rotation in demi-plie.

Of the 14 knees which were classified in the patellofemoral pain group, 11 demonstrated tightness in the ITB and three exhibited normal flexibility. In the group of 34 pain-free knees, 25 demonstrated normal ITB flexibility and nine legs demonstrated ITB tightness. The calculated chi-square value was 11.075 ($p < .01$), indicating that there was an association between ITB tightness and patellofemoral pain in ballet dancers.

The z scores for the Wilcoxon Rank Sum tests were 2.13 and 4.60

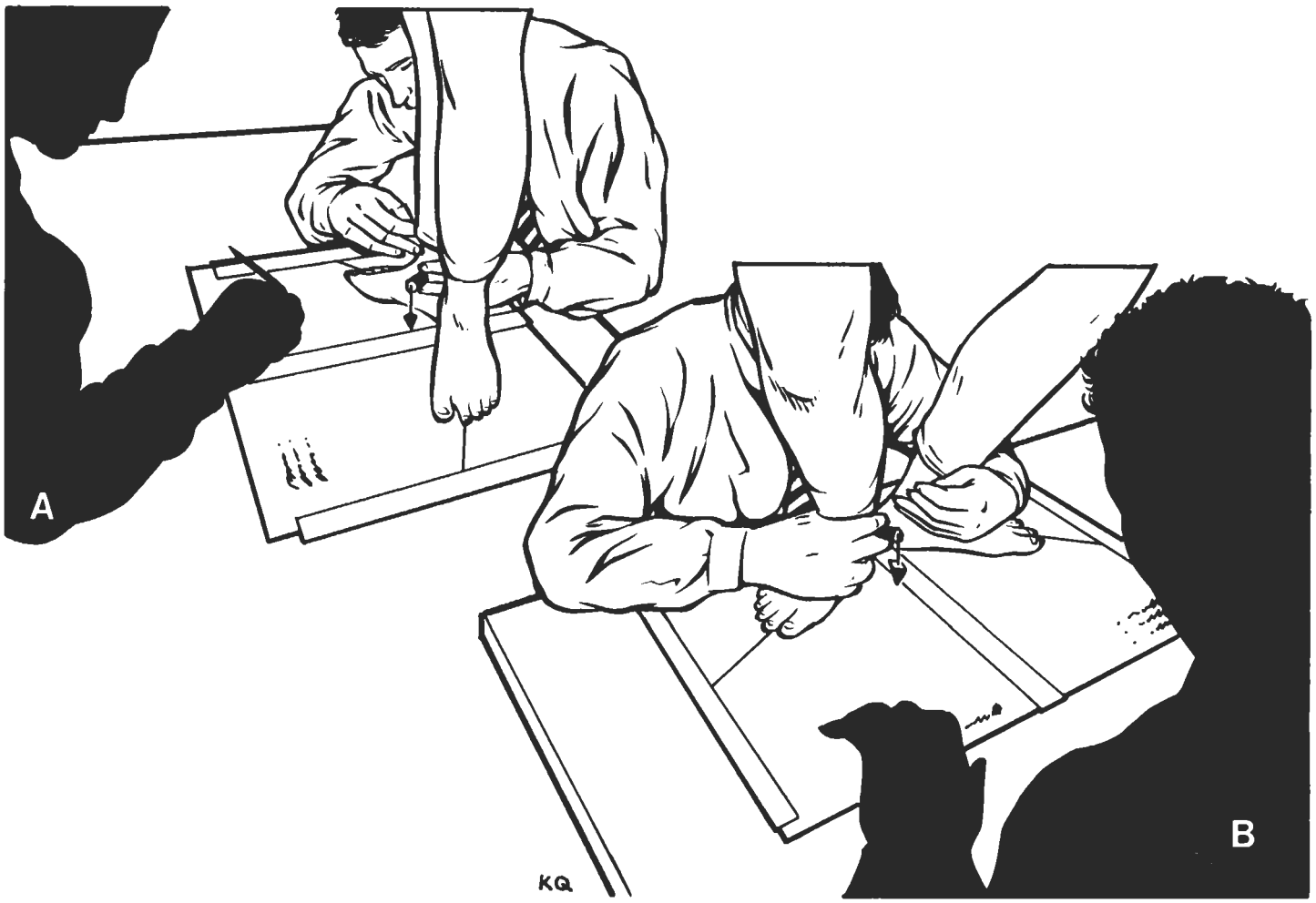

FIGURE 3. *A) Plumbline measurement to assess degrees of tibial rotation in first position. B) Measurement of tibial rotation during a demi-plie.*

There was an association between iliotibial band tightness and patellofemoral pain.

for first position turn-out and the demi-plie, respectively. The z score for turn-out was significant at the .05 level, and for the demi-plie, the z score was significant at the .01 level. The mean value of tibial external rotation standing in first position turn-out in dancers with tight ITBs was 61.0° degrees (SD = ±4.1°). Mean tibial external rotation for dancers with normal ITB length was 58.5° (±4.2°). The mean value for tibial external rotation during demi-plie for dancers with tight ITBs was 69.1° (±4.0°), and for dancers with normal ITB length, the mean value was 62.3° (±3.8°).

DISCUSSION

Results of this study support the findings of Reid et al (13) who reported that patterns of decreased flexibility in classical ballet dancers are positively correlated with an increased incidence of lateral hip and knee injuries. Clippenger et al (1) also found that there is a strong association between mechanical and anatomical limitations in ballet dancers and an increased incidence of patellofemoral pain.

Reid et al (13) proposed that patellofemoral pain in the dancers occurs secondary to adaptive shortening of the ITB. Because the demi-plie (partial knee flexion) requires a combination of hip abduction and external rotation, this leads to a shortening of the ITB. The fibrous slips, which the ITB sends to the patella, become integrated with the lateral retinaculum at the knee. When the knee goes into flexion during a demi-plie, the tight ITB will cause the patella to track laterally. A tight ITB pulls the patella laterally during the knee flexion movement and also externally rotates the tibia, which may

increase the valgus vector at the knee and, in turn, compound the excessive lateral tracking of the patella (9,15).

Torsional stresses at the knee are further exacerbated in the dancer who forces the turn-out. The ballet dancer will obtain the desired turn-out with the knees bent and then straighten the knees (7,9,15). When the knee is in flexion, the ITB is pulled posteriorly, which externally rotates the tibia and, thus, enables the dancer to achieve maximal turn-out. Simultaneously, the ITB pulls the patella laterally. In this position, with feet still fixed, the ballet dancer will straighten up, producing a large patellofemoral joint reaction force.

A tight iliotibial band pulls the patella laterally during the knee flexion movement and also externally rotates the tibia.

Most college-age ballet dancers have danced for many years using the same movement strategies. Over time, these excessive patellofemoral joint reaction forces due to abnormal patellofemoral alignment lead to damage of connective and contractile tissues associated with the patellofemoral joint and may create anterior knee pain.

CONCLUSION

Results of this study indicate that iliotibial band (ITB) tightness in ballet dancers may be a predisposing factor for the development of the patellofemoral pain, and that dancers with tightness of the ITB tend to compensate for the tightness during demi-plie with excessive external rotation of the tibia, which may further exacerbate the patellofemoral pain. Subsequent study should aim to determine if therapeutic intervention to preserve normal ITB flexibility will prevent or remediate impairments associated with patellofemoral pain in ballet dancers. JOSPT

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