Radiographic Evidence of Hip Microinstability in Elite Ballet

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Purpose: To determine prevalence, magnitude, and predisposing radiographic features of hip subluxation in elite ballet dancers. **Methods:** A cross-sectional investigation of professional male and female ballet dancers was performed using 5 plain radiographs. A "splits" anteroposterior (AP) radiograph was performed with legs abducted parallel to the trunk in the coronal plane (splits position; grand écart facial). Hip center position (HCP) was measured on standing AP pelvis and AP pelvis splits views and the difference calculated (subluxation distance) to determine prevalence and magnitude of femoral head subluxation. Student *t* test compared HCP on AP pelvis and splits radiographs. Pearson correlations were used to correlate splits HCP with radiographic measures of femoroacetabular impingement and dysplasia. **Results:** Analyzing 47 dancers (21 men, 26 women; 23.8 ± 5.4 years), mean HCP on standing AP pelvis was 9.39 ± 3.33 mm versus 10.8 ± 2.92 mm on splits radiograph, with mean subluxation distance of 1.41 mm ($P = .035$). Forty-two dancers' femoral heads translated laterally with splits positioning, and 17 dancers (36%) exhibited a "vacuum sign" (bilateral in 71% of subjects with at least 1 hip vacuum sign). There was strong positive correlation ($r = 0.461$, $P = .001$) with splits HCP and alpha angle (Dunn 45°), and moderate negative correlation ($r = -0.332$, $P = .022$) with subluxation distance and neck-shaft angle. In men, splits HCP increased as lateral center edge angle (CEA) decreased ($r = -0.437$, $P = .047$), as anterior CEA decreased ($r = -0.482$, $P = .027$), as Tönnis angle increased ($r = 0.656$, $P = .001$), and as femoral head extrusion index increased ($r = 0.511$, $P = .018$). In women, there was moderate negative correlation ($r = -0.389$, $P = .049$) with subluxation distance and neck-shaft angle. **Conclusions:** Hip subluxation occurs during splits in most professional ballet dancers, with a significantly greater magnitude of subluxation in women than men. Subluxation magnitude increases with increasing alpha angle and decreasing neck-shaft angle. In men, the magnitude increases with severity of dysplasia. Women had subluxation regardless of acetabular morphology but increased subluxation with decreased neck-shaft angle. This provides radiographic support for hip microinstability in elite ballet. **Level of Evidence:** Level IV, diagnostic.

The dynamic and static stabilizers of the hip work in synchronicity to prevent instability during normal physiologic motion.[1] The chondro-osseous congruity of the femoral head within the acetabulum provides inherent stability.[2-8] Further support is provided by the labrum and associated suction seal, capsule, ligamentum teres, and musculotendinous units crossing the joint.[1] Hip motion is primarily rotational, rather than translational.[9] Motion performed outside of normal, deemed "supraphysiologic," is generally not compatible with the restraints of normal anatomy.[10]

Elite ballet requires pushing beyond the normal physiologic range of motion to achieve desired techniques, often employing high degrees of flexion, abduction, and external rotation.[11,12] Supraphysiologic motion about the hip in ballet dancers may be obtained by either soft tissue laxity or osseous undercoverage.[11] Upwards of 66% of ballet dancers have been shown to have 4 or more Beighton criteria.[13] Further, the repetitive motion focused on gaining "turnout," flexed external rotation and abduction, may induce microtrauma (ligamentous creep) to the surrounding soft tissue, especially the iliofemoral ligament. Compromised integrity of any 1 or more of these restraints may

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predispose a vulnerability to instability or microinstability.[12,14-17]

Osseous constraint abnormalities may also permit an increased range of motion. Most ballet dancers exhibit characteristics of both dysplasia and femoroacetabular impingement (FAI).[18,19] Often this is a bilateral phenomenon that affects women more than men. Soft tissue laxity, combined with a lack of osseous constraint and supraphysiologic demands, may lead to microinstability of the hip (Fig 1).[12,15,20-23] Further, FAI and extra-articular impingement (trochanteric-pelvic) may both induce subluxation and microinstability owing to bony levering over a fulcrum.

Hip subluxations (measured as femoral head translation) at the extremes of motion have been previously revealed by magnetic resonance imaging (MRI).[10] However, no plain radiographic evidence currently exists, and the prevalence and magnitude of these findings have yet to be determined. The purpose of this study was to determine (1) prevalence, (2) magnitude, and (3) predisposing radiographic features of hip subluxation in a professional company of elite male and female ballet dancers. The authors hypothesized that the prevalence of subluxation (lateral femoral head translation) was at least 50%, with a mean of at least 1 mm translation, and with increasing dysplasia associated with increased subluxation.

Methods

Institutional review board approval was obtained to perform a cross-sectional radiographic investigation of professional ballet dancers. Inclusion criteria were adult volunteer subjects older than 18 years currently working in a professional ballet company. Anyone who did not wish to participate (n = 0), was not at least 18 years old (n = 7), was confirmed or possibly pregnant (n = 0), or had any history of hip surgery (n = 0) were excluded. Eligible subjects were offered enrollment, and informed written and verbal consent to obtain 5 radiographs of the pelvis and hips was obtained.

Radiographic Evaluation

All radiographs were performed on July 22, 2014. Subject-level demographics were recorded (date of birth, age, and gender), 5 plain radiographs of each participant were obtained (standing anteroposterior [AP] pelvis, left and right false profile, supine Dunn 45°, and AP pelvis splits) using a GE Definium 8000 machine (Fairfield, CT). A complete series was performed for all subjects and stored on a secure, Health Insurance Portability and Accountability Act–compliant picture archiving and communication system at the authors' institution. All measurements were made digitally on the institutional picture archiving and communication system (neck-shaft angle, lateral and anterior center edge angles (CEAs), Tönnis angle, alpha angle, femoral head extrusion index, and hip center position). All measurements were made by the senior author (J.D.H., Sports Medicine and Hip Preservation fellowship-trained, board-certified orthopaedic surgeon) at one point in time. (Appendix 1, available at www.

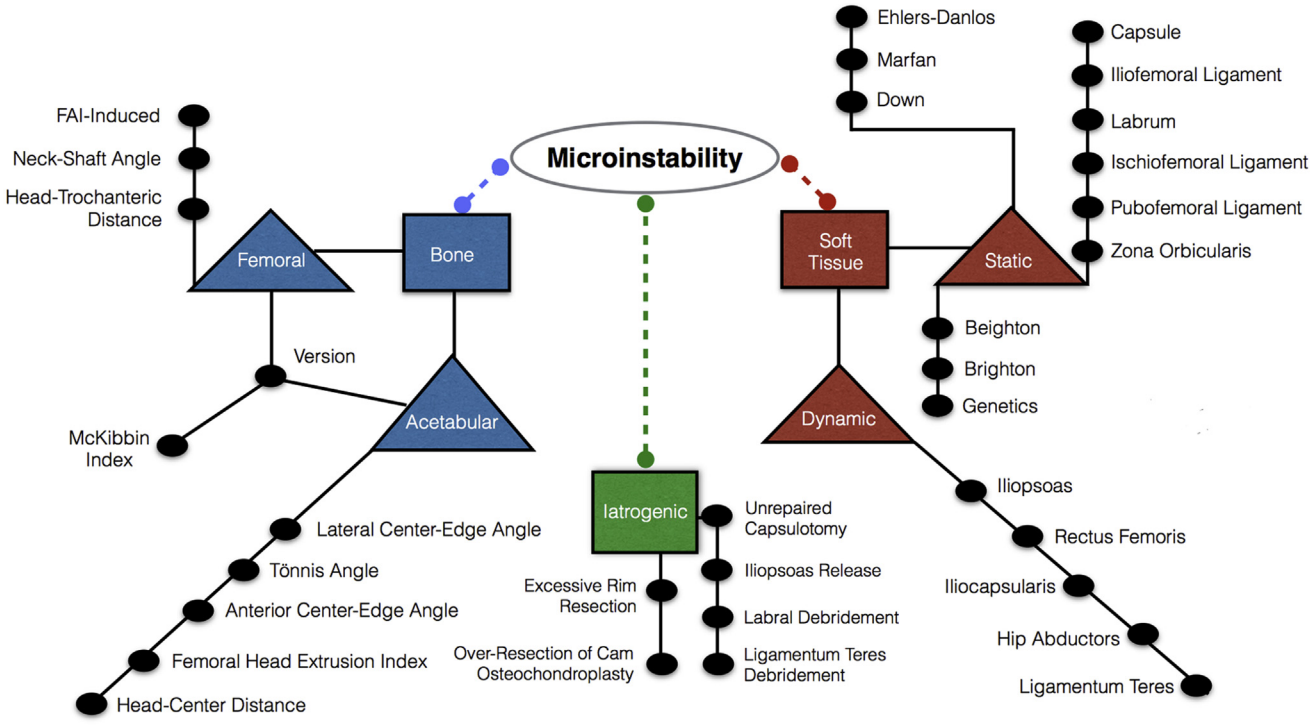

Fig 1. Spectrum of osseous and soft tissue contributions to hip microinstability. (FAI, femoroacetabular impingement)