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Original research

Impingement-type bony morphology was related to cartilage defects, but not pain in professional ballet dancers' hips

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ABSTRACT

Objectives: Professional ballet dancers may have hip bony morphology that predisposes them to cartilage or labral injury. However, the relationship between bony morphology and pathology has not been investigated in ballet. This study investigates associations between bony morphology, chondrolabral defects and hip pain in ballet dancers.
Design: Cross-sectional study.
Methods: 33 male and female professional ballet dancers, (mean age 27 years (range 19–39)), completed questionnaires with hip pain measured on a visual analogue scale; and underwent 3.0-T magnetic resonance imaging (3T MRI) to measure lateral centre edge angles (LCEA), alpha angles in the anterior and superior position, femoral neck-shaft angles (NSA) and acetabular version angles; and to detect acetabular labral tear and articular cartilage defects.
Results: Seventeen dancers (51.5%) had impingement-type (alpha angle > 50.5° or acetabular version <10° or >20°) and 19 (58%) had instability-type (LCEA < 25° or NSA > 135°) bony morphology. Cartilage defect prevalence was higher in dancers with impingement-type bony morphology (n = 14) compared to those without impingement-type morphology (n = 4, p = 0.001). There was no relationship between instability-type bony morphology and cartilage defects (p > 0.05). There was no relationship between labral tears and bony morphology (p > 0.05). Neither chondrolabral pathology nor any morphological feature were associated with hip pain (p > 0.05 for all).
Conclusions: Impingement-type bony morphology was related to cartilage defects, but not labral tear. Hip pain was not associated with pathology or bony morphology. Longitudinal studies are warranted to determine if bony features, such as cam morphology, acetabular retroversion or anteversion, are precursors to symptomatic hip joint injury or osteoarthritis.

1. Introduction

Classical ballet is a unique physical activity that involves extreme hip range of movement (ROM), and professional ballet dancers have hip bony morphology that differentiates them from athletes.[1] Bony morphological features that may benefit a dancer by enabling ballet-specific hip joint ROM, such as acetabular dysplasia,[2] high femoral neck-shaft angles,[1] low acetabular and femoral version angles,[1,3] and greater concavity of the femoral head-neck junction,[1,4] have been found in elite ballet dancers. Certain bony features, although potentially advantageous, may predispose a dancer to hip joint injury; however, a more normal morphology may limit ballet-specific function and contribute to injury.

The hip can be repeatedly exposed to altered loading in ballet due to femoroacetabular impingement and subluxation at extreme ROMs.[5,6] Greater femoral head subluxation has been demonstrated in male and female elite ballet dancers with impingement-type morphology, such as higher alpha angles and lower femoral neck-shaft angles, while performing the splits.[5] This loading may be a contributing factor to the high incidence of cartilage defects found in elite ballet dancers,[4,7] and the detection of cartilage defects in male dancers' hips at an earlier age compared to athletes.[7] Even though studies have found a similar incidence of acetabular labral tear in ballet dancers compared to normal controls and non-dancing athletes,[4,8] labral tear and cartilage defects co-exist in ballet dancers' hips, independent of ageing.[8] The exact nature

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Table 1
Ballet dancer characteristics (n = 33).

Sex, % male (n)	45 (15)
Age, years	28 (8)
Weight, kg	58 (23.5)
Height, m	1.69 (0.34)
BMI, kg/m^2	20.58 (3.01)
Hip VAS	0 (1)

Data are presented as median (interquartile range (IQR)), unless otherwise indicated. BMI, body mass index; VAS, visual analogue score.

of this relationship is unknown, but a dancer's bony anatomy and loading profile may negatively impact hip joint health.

Chondrolabral injury and hip osteoarthritis (OA) have been linked to abnormalities of acetabular undercoverage, and cam morphology in non-dancing populations.[9–11] It is plausible that instability-type bony morphology, such as acetabular dysplasia, that may contribute to optimal ballet function, may predispose the dancer to chondrolabral injury and subsequent premature hip OA.[2] Cam morphology has also been identified in elite ballet dancers and could increase the risk of joint injury due to mechanical impingement and subluxation.[1,2] Due to the extreme ROMs employed by dancers, subtle variations of bony morphology may be detrimental to hip joint health. The relationship between bony morphology and chondrolabral injury in ballet dancers has not been studied, and the findings could improve our understanding of the potential contributing factors to hip joint injury and OA.

The objectives of this study were to investigate the relationship between bony morphology of the hip and the prevalence of labral tear or cartilage defects; and to determine if hip pain is related to these factors in professional male and female ballet dancers.

2. Methods

Participant characteristics of the male and female professional classical ballet dancers are included in Table 1. Seventy-nine percent (n = 54) of the ballet company volunteered, and 33 dancers where included as they met inclusion criteria of aged 18 years or older, have danced for more than 10 years and were employed by the company fulltime. Exclusion criteria included an injury preventing dancing at the time of testing (n = 3, all non-hip related), a history of hip trauma or serious injury (n = 0), hip surgery (n = 0), congenital hip disease (n = 0), inflammatory joint disease (n = 0), or systemic, metabolic, or neurological disorders (n = 0), as well as those with contraindications to MRI (pregnancy, claustrophobia, metal implants) (n = 4), and unavailable at the time of testing (n = 14). Ethics was approved by La Trobe University Human Research Ethics Committee (reference number S16/100), and the participants provided written informed consent.

Participants completed a questionnaire about their medical and injury history. A visual analogue scale (VAS) was used to measure hip pain, with 0 = no pain and 10 = the worst imagined pain. Heights and weights were measured and the body mass index (BMI) of each participant was calculated.

Participants were scanned in a standardized supine position, with straps and padding to maintain neutral spine, pelvic and hip alignment. Non-contrast images were performed with a 3.0-T Siemens Trio scanner (Siemens, Erlangen, Germany) using an 8-channel phased array body coil. Left and right hips were imaged separately. Further detail on the MRI protocol and the bony morphology measurement procedure has been previously published,[1] and is included in Supplementary file A. Images were analysed with InteleViewer (version 4-3-4P95).

The presence or absence of labral tear or cartilage defect on MRI was scored using previously validated methods.[12] Absence of a labral tear was scored if a homogenous low signal intensity labrum was identified, with the base sitting flush with the acetabulum, or focal increased signal confined to the labrum. Presence of a labral tear was scored if a line of high signal was detected coursing from the articular side through the base, or into the labral substance, with or without labral distraction.[12] The articular cartilage was scored as intact if no cartilage defect was present, or if there was only signal alteration within the cartilage. A cartilage defect was classified as present if there was any cartilage loss on either the acetabular or femoral surface.[12] Cartilage defects were also graded; grade 1 was defined as a focal partial-thickness defect; grade 2 was defined as a cartilage defect that ranged from a single large or several partial thickness defects to full thickness cartilage loss on either the femoral head or acetabulum. When scoring labral tear or cartilage defects we chose not to include high signal intensity confined to the labrum or cartilage to reduce the potential of type 1 error.[12]

Cartilage defects and labral tears were scored by one experienced musculoskeletal radiologist. The morphological parameters were measured by an experienced physiotherapist, who was trained by the musculoskeletal radiologist. Both raters were blinded to all participant data. The intra-rater reliability of measuring all angles has previously been reported, and was excellent with the intraclass correlation coefficients (ICCs) (2-way mixed, absolute agreement) ranging from 0.86 to 0.96 (95% confidence intervals (CI): 0.72–0.98).[1] The ICCs, 95% CI and minimal detectable change values (range: 2.9°–5.6°) are shown in Table 1 of the Supplementary file.

Normative values for bony morphological measures have not been established in ballet dancers; therefore, normal population values have been applied. Acetabular dysplasia was defined as a lateral centre edge angle (LCEA) < 20°, and borderline dysplasia with a LCEA of < 25°.[13] Acetabular overcoverage or pincer morphology was defined as a LCEA ≥ 39°.[14] Normal central acetabular version angle ranges between 15–20°, with acetabular retroversion defined as <10°.[14–16] As hip external rotation is the foundation ballet, moderate anteversion of >20° was used as the upper limit.[14] Normal femoral neck-shaft angles (NSA) range between 125°–135°, with coxa valga defined as >140°.[14,17] Cam morphology is quantified by the alpha angle, and abnormal thresholds vary in the literature, such as >50.5°, >55° and >60°.[18–20] The 95% reference interval for alpha angles in normal hips is 32°–63°,[21] but due to extreme ROMs used in ballet a conservative alpha angle of >50.5° was set as the cut-off value.[18] Impingement-type bony morphology (yes/no) was assigned if at least one of the following features was detected in a dancer: LCEA ≥ 39°, acetabular version <10° or >20°, alpha angle >50.5° or NSA <125°. Instability-type bony morphology (yes/no) was assigned if at least one of the following features was detected: LCEA < 25° or NSA > 135°.

Data were analysed using statistical software (SPSS version 21, SPSS Inc., Chicago, IL, USA). Data for one hip of each participant was analysed; the hip with a cartilage defect was chosen, unless there were bilateral cartilage defects, in which case the hip with the highest cartilage score was used. If both hips had the same score, a coin toss determined the chosen hip. There were 15 right and 18 left hips. All data were assessed for normality using the Shapiro–Wilk test. Mann–Whitney *U* test or independent *t*-tests were used to evaluate continuous variables such as morphological measures, age, weight, height, BMI, and hip VAS in dancers. These tests were also used to compare the hip VAS and bony morphological measures between dancers with and without cartilage defects or labral tear, as well as comparing hip VAS between dichotomised bony morphological measures, using cut-off values. Pearson's chi-square test was used to compare dichotomised morphological measures with cartilage defect and labral tear presence or absence. Pearson's correlation coefficient was used to evaluate correlations between hip VAS and the morphological parameters. Due to multiple compar-