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The FADIR test accuracy for screening cam and pincer morphology in youth ice hockey players

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ABSTRACT

Objectives: Aim of this study was to evaluate the flexion-adduction-internal rotation (FADIR) test accuracy for screening cam and pincer morphology in youth male ice hockey players without diagnosed hip disorders.
Design: Cross-sectional study.
Methods: Seventy-four ice hockey players with a mean age of 16 years (range: 13–20 years) were assessed unilaterally. The presence of cam and pincer morphology was evaluated using the FADIR test and magnetic resonance imaging (MRI) (reference standard). Positive FADIR test consisted of groin pain during the maneuver, while positive MRI findings consisted of (1) pure cam, pure pincer or combined morphology and acetabular labral alterations, or (2) pure cam or combined morphology and acetabular labral alterations. Sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values were calculated.
Results: For pure cam, pure pincer or combined morphology as positive MRI findings, the FADIR test demonstrated a sensitivity of 41%, specificity of 47%, positive likelihood ratio of 0.78, negative likelihood ratio of 1.24, positive predictive value of 19% and negative predictive value of 73%. For pure cam or combined morphology as positive MRI findings, the FADIR test showed a sensitivity of 60%, specificity of 52%, positive likelihood ratio of 1.24, negative likelihood ratio of 0.78, positive predictive value of 16% and negative predictive value of 89%.
Conclusions: The FADIR test is inadequate for screening cam and pincer morphology in youth ice hockey players without diagnosed hip disorders because of the large number of false positive test outcomes.

1. Introduction

Femoroacetabular impingement (FAI) is a hip pathomechanism mainly induced by bony deformities at the proximal femur (cam morphology) and/or acetabulum (pincer morphology) at end range of hip flexion and internal rotation.[1] This pathomechanism may lead to acetabular labral tears, hip pain and sports disability, therefore to development of FAI syndrome. In addition, the presence of cam morphology has been associated with an increased risk of developing hip osteoarthritis.[2] Ice hockey players are athletes at high risk for developing FAI syndrome and potentially hip osteoarthritis.[3,4] Indeed, they present with a high prevalence of cam morphology[5–7] and perform hip motions during skating that may repetitively induce FAI and cause intra-articular hip damage.[4,8]

Whilst the prevalence of cam morphology is around 23% in asymptomatic subjects,[9] it was reported to range between 45% and 75% in ice hockey players.[5–7] The high prevalence of cam morphology in ice hockey players might result from bone adaptation in response to sport-specific vigorous hip loading during skeletal growth, as shown in youth soccer players.[10] Indeed, high and specific mechanical loading on the femoral growth plate may influence bone modelling and lead to abnormal bone formation.[11] In addition, repeated hip movements performed by ice hockey players while skating, such as hip flexion and internal rotation at the end of the recovery phase of the hockey stride, may promote the occurrence of the FAI pathomechanism.[4]

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Since the presence of cam and pincer morphology may result in the development of FAI syndrome and early hip osteoarthritis,[1,2] regular hip morphology screening in athletic populations such as youth ice hockey players is essential for identifying at-risk athletes, and providing them with timely preventive measures. These measures could consist of adjusting athletic activities during a period of skeletal growth[10] or implementing a physiotherapy-led rehabilitation program.[12] Hip physical examination tests may be more practical, convenient and cheaper than standard imaging evaluations for hip morphology screening purposes. The most commonly used hip examination test for FAI is the flexion-adduction-internal rotation (FADIR) test.[13] This test replicates the mechanical abutment of the femoral head against the anterosuperior portion of the acetabulum,[13] where also acetabular labral tears most often occur.[14] The FADIR test was recently shown to have a high sensitivity (94%) and a low specificity (9%) for the diagnosis of FAI syndrome in patients presenting with groin pain or symptoms highly suggestive of hip pathology.[15] The diagnostic accuracy of the FADIR test has only been investigated in patients with high suspicion of FAI syndrome and high likelihood of a positive test, thus providing sample-biased results.[15] The aim of this study was to evaluate the FADIR test accuracy for screening cam and pincer morphology in youth male ice hockey players without diagnosed hip disorders.

2. Methods

A total of 74 male youth ice hockey players belonging to the same professional club were evaluated. Data were collected in a previously published study, which investigated the prevalence of cam and pincer morphology in youth ice hockey players, and their association to hip muscle strength, range of motion and on-ice physical performance.[5] Mean (±SD) age and body mass index of the players were 16 ± 2 years (range: 13–20 years) and 22 ± 3 kg/m^2 (range: 17–27 kg/m^2), respectively. Twenty-four players were defenders, 19 forwards, 13 wings, 10 centers and 8 goalies with a mean (±SD) playing experience of 11 ± 2 years (range: 4–16 years). Players were excluded if they already had a diagnosis of FAI syndrome and/or if they had previous hip surgery. The study was conducted according to the Declaration of Helsinki and the protocol was approved by the local ethics committee. All players and parents of minor players signed an informed consent before participating in the study. The accuracy of the FADIR test for screening cam and pincer morphology was evaluated by comparing FADIR test outcomes with magnetic resonance imaging (MRI) findings (reference standard). Only unilateral MRI assessments were performed to reduce costs. Since the prevalence of cam morphology seems to increase with decreasing hip internal rotation range of motion (ROM),[16] only the hip that demonstrated less internal rotation ROM on a hip examination chair[17] was further evaluated. If the side-to-side difference in hip internal rotation ROM was <1°, the evaluated hip was randomized using a computer random number generator. In addition, self-reported hip pain and function was assessed using the Hip Outcome Score (HOS).[18,19]

All the FADIR tests were performed by a single investigator with 5 years of experience as a sports physical therapist in the clinical evaluation and treatment of hip patients and athletes. The investigator was blinded to MRI findings. With the athlete lying supine on a treatment table, the investigator passively moved the hip in a combination of flexion, adduction and internal rotation until end of ROM was achieved.[20] A positive FADIR test was determined by groin pain experienced by the athlete during the test maneuver.

The presence of cam and pincer deformities, as well as the presence of acetabular labrum alterations, was assessed with non-contrast MRI. A 1.5 Tesla high-field system (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) was used with a body matrix phased-array surface coil and a spine matrix coil. The following sequences were acquired: a coronal intermediate-weighted sequence with fat saturation, a coronal T1-weighted sequence, a sagittal water-excitation 3-dimensional (3D) double-echo steady-state sequence, a transverse short-tau inversion recovery sequence, and a transverse oblique water-excitation true fast imaging with steady-state precession 3D sequence. After MRI examination, additional radial reformations of the transverse oblique true fast imaging with steady-state precession 3D sequence were reconstructed to assess the osseous contour of the femoral head-neck junction. MRI examinations were analysed by two experienced radiologists, who were blinded to FADIR test outcomes. The presence of cam morphology was determined by means of the alpha angle. The alpha angle was measured on radial oblique MRI at the anterosuperior segment as the angle between the axis of the femoral neck and the line from the center of the femoral head to the point where the distance from the center of the femoral head to the peripheral contour of the femoral head exceed the radius of the femoral head (Fig. 1A).[21] An alpha angle >60° was considered positive for the presence of cam morphology.[21,22] The presence of pincer morphology was determined by means of acetabular version and depth. Acetabular version was measured on the oblique transverse MRI at the level of 2.5 mm below the most cranial portion of the acetabular rim, with an angle drawn between the sagittal plane and a line connecting the anterior and posterior borders of the acetabulum (Fig. 1B).[23] A positive angle indicated acetabular anteversion and a negative angle indicated acetabular retroversion.[24] The measurement of acetabular depth was performed on the oblique transverse MRI at the level of the center of the femoral head, with positive values indicating that the center of the femoral head was located lateral to the line connecting the anterior and posterior border of the acetabulum, whereas negative values indicated that the femoral head was located medial to this line (Fig. 1C).[25] Acetabular retroversion and/or acetabular depth ≤3 mm were considered positive for pincer morphology.[25] The presence of acetabular labral alterations was evaluated on radial MRI as a linear band of high signal intensity detected in the labrum (Fig. 1D).[25] Since the presence of cam, but not pincer, morphology has been recently associated with an increased risk of developing hip osteoarthritis,[2] the accuracy of the FADIR test for screening cam and pincer morphology was evaluated by using two different combinations of morphology types as positive MRI findings: (1) the presence of pure cam, pure pincer or combined morphology together with the presence of acetabular labral alterations, and (2) the presence of pure cam or combined morphology (without pure pincer) together with the presence of acetabular labral alterations.

The HOS is a self-reported questionnaire specifically developed for assessing hip pain and function of young and active subjects.[18,19] Two independent scores were obtained: one for activities of daily living (HOS ADL: 19 items, 17 scored) and one for sport activities (HOS sport: 9 items, 9 scored). The scores range from 0 to 100, where 100 indicates the best possible score. The HOS has previously been shown to be reliable (i.e., intraclass correlation coefficients of 0.94 for HOS ADL and 0.89 for HOS sport) and valid when correlated with other self-reported measures.[19]

The number of true positive (positive FADIR and MRI), false positive (positive FADIR, negative MRI), false negative (negative FADIR, positive MRI) and true negative (negative FADIR and MRI) FADIR test outcomes was used for the calculation of sensitivity, specificity, positive and negative likelihood ratios, positive and negative predictive values, and disease prevalence.[26,27] Results are presented as mean and 95% confidence intervals (CI) or mean ± SD. One-way ANOVAs were used to compare age, alpha angle, HOS ADL and HOS sport between athletes with true positive, false positive, false negative and true negative FADIR test outcomes. Tukey's HSD tests were used for *post-hoc* pairwise comparisons of the means. Statistical analyses were performed using Microsoft Excel 14.6.0 (Microsoft

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