ORIGINAL ARTICLE

Hip passive range of motion and frequency of radiographic hip osteoarthritis in former elite handball players

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Objective: To establish the relation between handball playing, passive hip range of motion (ROM), and the development of radiological hip osteoarthritis (OA) in former elite handball players. Two related issues are addressed: (*a*) the relation between long term elite handball playing and the incidence of hip OA; (*b*) the relations between hip ROM, OA, and pain.
Methods: Data on 20 former elite handball players and 39 control subjects were collected. A questionnaire yielded personal details, loading patterns during physical activity, and previous lower limb joint injury. Bilateral radiographs were analysed to diagnose and classify hip OA. Passive hip ROM was measured bilaterally with a goniometer.
Results: A close relation was found between long term elite handball practice and the incidence of hip OA: 60% of the handball players were diagnosed with OA in at least one of the hip joints compared with 13% of the control subjects. Passive ROM measured in the handball players was significantly lower for hip flexion and medial rotation and higher for abduction, extension, and lateral rotation than the control values. The handball players with OA reported less pain in the hip joints during daily activities than the control subjects with OA.
Conclusion: The risk of developing premature hip OA seems high for retired handball players and significantly greater than for the general population. Pain and discomfort represent two difficult diagnostic challenges to the sports physician, as the repetitive nature of movements that are specific to handball can lead to alterations that are rarely seen in the general population.

Osteoarthritis (OA) is a common joint disorder sometimes characterised by a reduced range of motion (ROM),[1–4] pain,[1 4 5] and disability.[3 6] The prevalence and severity of OA increase with age.[7 8] The joint degeneration is characterised by cartilage and bone degeneration.[6] Radiographic classification would be an ideal evaluation variable for OA diagnosis. Indeed, radiographs reveal both cartilage alteration (joint space width, JSW) and the bone response (osteophytes, sclerosis, cysts).[9 10]

Hip OA is a major cause of disability in the elderly, affecting up to 25% of the European white population over the age of 55.[5] Most senior citizens show a strong desire to remain able to perform activities of daily living and even to exercise regularly.[8] ROM is thus a particularly meaningful component of fitness for these people, as a lack of flexibility can restrict participation in key activities of life. A diminished ROM may also contribute to the likelihood of falls, because of greater instability.[11]

In addition to aging, the incidence of hip OA may be increased by a number of other risk factors including hip or acetabular dysplasia,[12] genetic factors,[13] occupational workloads,[14 15] joint injuries,[2 16] and anthropometric factors such as body mass index (BMI).[17 18] Intense sports training has also been shown to increase the risk of developing hip OA.[5 16 19 20] This is particularly true for sports involving traumatic loading such as soccer[16 21] and basketball.[2]

Team handball has been an Olympic sport since 1972. In Europe, it is one of the most popular team sports, after soccer and basketball. Two teams compete during two 30 minute periods on a 20 × 40 m indoor court. Each team has six field players, one goalkeeper, and five substitutes.[22] Handball places heavy mechanical loads on the hip joint. Cutting movements and rapid stopping and acceleration intended to avoid obstructions are often used. The ability to perform these phases in rapid succession is a major component of competitiveness, but cumulative effects of weight bearing are produced on the locomotive apparatus.[19]

To demonstrate the importance of introducing control procedures for competitive handball players, data are needed to clearly show that long term handball practice can lead to hip OA and that the risk is higher than in a normal control population. The aim of this study was to further quantify the passive ROM in the hip joint, the prevalence of radiographic hip OA, and the level of self reported hip pain in retired elite handball players. This investigation forms part of a wide ranging programme aimed at developing measures to prevent an overload of the legs in elite and recreational athletes.

METHODS

Both experimental and control subjects participated in a structured protocol. The methods for data collection were interviews, hip radiography, clinical examination, and functional measurements.

Subjects

The experimental group comprised all 37–54 year old former elite male handball players from two clubs. All had played handball for at least 15 years, with a minimum of four hours of training a week. They were all physically active and free from injury at the time of testing.

The control subjects were recruited during consultations for severe polytraumatism in the Department of Orthopaedics. The control group was matched for age and body weight, as these two factors are of prime importance in the development of OA. Men with malformations of or trauma to the hip joint were excluded from both the experimental and control groups.
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Table 1 Subject characteristics

	Handball players (n = 20)	Controls (n = 39)	p Value*
Age (years)			
Mean (SD)	44.9 (4.7)	42.5 (4.7)	0.06
Range	37–54	35–53	
Height (cm)			
Mean (SD)	177.8 (6.7)	174.6 (8.2)	0.13
Range	168–192	150–190	
Weight (kg)			
Mean (SD)	80.8 (11.2)	75.2 (16.0)	0.16
Range	65–100	43–110	
Body mass index (kg/m^2)			
Mean (SD)	25.1 (3.0)	23.9 (3.7)	0.19
Range	20–32	17–32	
Training volume (hours/week)			
Mean (SD)	6 (1.4)	0.3 (1.1)	<0.0001
Range	4–9	0–5	
Lifetime handball training (years)			
Mean (SD)	24.8 (7.1)	0.5 (1.9)	<0.0001
Range	15–40	0–10	
Heavy worker			
% (No)	19 (4)	51.2 (21)	

*Student's *t* test used.

Information on these factors was obtained from personal interviews and radiographic examination. Table 1 presents the characteristics of both groups. All study participants gave their informed consent before testing began.

Interview
The questionnaire was divided into sections designed to accrue information on risk factors for hip OA: personal details (birth date, first official elite game, retirement from elite handball, playing position), lifetime occupational loading, years and hours a week of athletic training, lower limb pain or injury, family medical history, and current medical conditions of lower limb joints (medical treatments and dysfunction in lower limb joints). The interview was based on the questionnaire responses and used open ended questions. The method is described in detail elsewhere.[16] The main characteristics and background factors were selected (table 1).

Hip radiography
All the subjects had a radiographic examination of the hip. The joint was internally rotated, with an angle of 15–20° subtended between the insides of the feet, which is a position consistent with normal functional or cyclical loading of the joint. The anatomical hip values were established from analysis at a 1:1 scale on radiographs obtained during weight bearing in the coronal plane using the Lequesne false profile. The radiographic criteria were used to discriminate between healthy and degenerative hips. The radiographic classification of Kellgren and Lawrence,[23] with OA scored on a scale of 0 to 4, was followed to diagnose the severity of the disease. The radiographs were also used to determine the JSW and its localisation, as well as to detect osteophytes, osseous cysts, and subchondral sclerosis. This measurement provides information on the state of the tissue: both its thickness and its compressibility when under a load. JSW measurements are more reliable when radiographs are taken with the hip joint bearing weight, as this ensures that the femoral head is pressing into the acetabulum.[9] The radiographs were blind analysed by the fourth author (FD) after all had been collected. The classification, material, and method were unchanged between the analysis sessions.

Clinical examinations and functional measurements
The clinical examinations and quantitative measurements were performed by the second author (GP). The passive ROM

was measured bilaterally for the hip and knee with a goniometer and expressed in degrees. Measurements were made for all joint actions: hip flexion (subject supine, knee flexed at 90°), extension (subject prone, knee extended), medial and lateral rotation (subject prone, knee flexed at 90°), abduction and adduction (subject supine, knee extended; hip flexed at 10° for adduction); knee flexion (subject supine, hip flexed at 90°) and extension (subject supine, leg stretched). To enhance the reliability of the ROM measurements, the standard recommendations were followed.[3 24] For each action, the protocol provided the starting position for subject and therapist, reference points for the pivot, and the distal points of the goniometer. The joint motion was continued until the action was completed or the pain threshold was reached. In the case of pain, the therapist identified its precise location. Pain in daily activities was measured using the Western Ontario and McMaster University (WOMAC) pain subscale,[25] which is composed of five items and was used as a 100 mm visual analogue scale. Functional status in daily activities was assessed using the Lequesne index and WOMAC functional subscale, both of which are usually used in exploration of the lower limb OA.[25 26] The Lequesne score is noted from 0 to 24 points, with 0 corresponding to normal function and 24 to a maximal handicap; the WOMAC functional subscale is composed of 17 items and was used with the Likert scale.

Statistical analysis
Normal distribution (Kolmogorov-Smirnov test) and homogeneity of variance (Fisher F test) were confirmed for each variable and allowed parametric statistics (Statview 5, Abacus, 1999). Statistical significance was accepted at $p < 0.05$. Students *t* test was used to compare subject characteristics and passive ROM; the χ^2 test (correction of Yates) was used to compare the incidence of hip OA. The Pearson correlation coefficient established the relation between ROM and OA, pain and JSW. The Mann-Whitney U test was used to compare the functional and pain values.

RESULTS
Interview
There were no cases of cartilage damage, surgery to the lower limbs, medication for the hip, or family medical antecedents of hip OA. The percentage of subjects reporting heavy work was higher in the control group than in the experimental

Table 2 Radiographic results from the Kellgren and Lawrence scale

Stage	Kellgren & Lawrence criteria	Handball players	Controls
0	Absence of osteophytes		
1	Doubtful osteophytes		
2	Minor osteophytes and/or subchondral sclerosis and/or osseous cysts	2	1
3	Osteophytes and moderate decrease in JSW	8	3
4	Osteophytes and large decrease in JSW	2	1

JSW, Joint space width.

group: only 20% (n = 4) of the handball players had high exposure to physical loads compared with 51.2% (n = 21) of the control subjects. Two of the former handball players met the criteria for obesity,[17][18] with BMI >30 kg/m^2; one was a former goalkeeper. Interestingly, neither showed any sign of hip OA. One control subject had a BMI >30 kg/m^2, and the beginning of hip OA was observable.

Hip radiographic examination
A high incidence of hip OA was noted in the former elite handball players: 60% (n = 12) were medically diagnosed with OA in at least one of the hip joints compared with 13% (n = 5) in the control group. This difference was significant (χ^2 = 11.07). Table 2 shows the results for the two groups obtained on the Kellgren and Lawrence radiographic classification. In the experimental group, the thickness of the joint cartilage was more altered in the left hip (20–100% of the JSW) than in the right hip (20–50% of the JSW). The concordance between the dominant leg and the side of hip OA was not significant (p = 0.27). The decrease in JSW was most often located in the anterolateral quadrant (n = 6) and on the anterior (n = 3) and posterior (n = 2) wall of the acetabulum. Osteophytes were located on the posterior and anterior horns and under the fovea. Osseous cysts were located in the anterior superior part of the femoral head.

Clinical examinations and functional measurements
Table 3 shows the values for passive ROM of the hip and knee. Hip flexion and medial rotation appeared significantly reduced (both hips) in the handball players compared with the ROM in the control group (p = 0.03, p = 0.02). Extension, abduction, and lateral rotation were higher in the handball players (p = 0.00, p = 0.01, p = 0.00). The adduction was distorted because it was combined with low flexion of the hip. The knee joint presented no deficit in either flexion or extension. Comparison of passive ROM between the hips with radiographic OA and healthy hips showed that flexion, adduction, and medial rotation were significantly higher in the healthy hips. Extension appeared higher in the hips with OA (p = 0.00). A negative correlation was found between ROM in flexion and medial rotation and the severity of hip OA evaluated on the Kellgren and Lawrence scale (p = 0.00, r = −0.85).

Table 4 shows the functional and pain status of the two groups. No significant differences were found between the Lequesne score and the WOMAC functional subscore of the players with OA compared with those of the controls with OA (p = 0.057, p = 0.8). The Lequesne index and the WOMAC functional subscale indicated that the players with OA had difficulty going up and down stairs and getting in and out of cars. When pain was present, it was localised in the greater

Table 3 Passive range of motion of the hip joint and knee

	Handball players (n = 20)		Controls (n = 39)		Total hips (n = 118)	
					OA hips (n = 21)	Healthy hips (n = 97)
	Right hip	Left hip	Right hip	Left hip		
Flexion (°)						
Mean (SD)	111 (7)	112 (13)	119 (7)	118 (6)	111 (15)	117 (8)
Range	90–120	70–120	100–120	100–120	70–120	90–120
Extension (°)						
Mean (SD)	13 (8)	12 (9)	4 (2)	5 (3)	11 (10)	6 (6)
Range	5–40	5–40	0–5	0–10	0–40	0–40
Abduction (°)						
Mean (SD)	40 (6)	39 (7)	28 (4)	28 (4)	34 (11)	32 (7)
Range	30–50	20–50	20–35	20–35	20–50	20–50
Adduction (°)						
Mean (SD)	22 (10)	22 (11)	24 (4)	25 (5)	19 (8)	25 (7)
Range	10–40	5–40	20–30	3–30	5–40	3–40
Lateral rotation (°)						
Mean (SD)	29 (9)	29 (7)	21 (3)	23 (3)	25 (9)	25 (6)
Range	10–50	10–40	10–25	20–30	15–50	10–50
Medial rotation (°)						
Mean (SD)	16 (7)	16 (8)	20 (3)	23 (4)	14 (7)	22 (4)
Range	5–30	0–30	10–25	10–30	0–30	10–30
	Right knee	Left knee	Right knee	Left knee		
Flexion (°)						
Mean (SD)	121 (4)	121 (4)	120 (0)	119 (3)		
Range	120–140	120–140	120–120	110–120		
Extension (°)						
Mean (SD)	0	0	0	0		
Range	0	0	0	0		

OA, Osteoarthritis.

trochanter and in the inguinal level. The handball players reported little pain during normal walking; however, rising from the seated position appeared to produce the most discomfort. Overall, the players with OA experienced minor pain in the hips, with a median value of 15 on the WOMAC pain subscale. This score did not correlate with the narrowing percentage of JSW (p = 0.09). The pain was significantly less in the players with OA than in the five controls with OA (p = 0.03).

In the controls with OA, the Lequesne and WOMAC functional median values rose to 5 and 6. The median value for pain was 70 for the subjects with OA. The Pearson correlation coefficient between pain and the narrowing percentage of JSW was significant for the controls with OA (p = 0.00), and a high correlation was found (r = 0.92).

DISCUSSION

The results of this study indicate an association between elite handball practice and premature hip OA. When age, physical work, loading during a game, and BMI were taken into consideration,[17] the results suggest an association between physical load and hip OA. The incidence of hip OA in the experimental group (60%) was higher than in the control group (13%). Our study thus clearly places intensive handball playing among other high risk activities such as soccer (32%, mean age of 47.6;[16] 49%, mean age of 56.1[21]), fencing (35%),[27] rugby, and tennis (16%).[28] The incidence of OA measured in the control group was similar to the values reported in the literature (1–10%).[29–31]

The type of sport, the length of time it has been practiced, and the playing level have all been suggested to contribute to the early appearance of hip OA.[32] The present study confirms this finding. Indeed, our study was made up of players with a lower mean age (44.9) than normal for developing hip OA (55–70).[29–31] This observation supports the concept that elite and intense handball training may contribute to the appearance of hip OA. The risk of undergoing total hip replacement is increased 4.5-fold after the age of 50 in athletes.[32] This risk is increased in handball players because the joint loading measured during play is above the physiological limits of cartilage.[19] Cartilage wear can also be the result of being overweight,[17 18] but in the present study high BMI was not associated with hip OA. The accumulation of heavy loads, which strengthen muscles and ligaments, may decrease hip ROM, which is a characteristic sign of OA.[1–4] The association between OA and BMI remains unclear.[18] The OA noted in this study was mostly located anterolaterally. Handball thus seemed to cause a localised overload to the cartilage, contributing to its degradation. The repeated impacts to the anterior wall of the acetabulum and the tractions at the level of the posterior horn were probably responsible for the localisation of osteophytes. The

What is already known on this topic

- Elite handball players sustain specific loads to their lower limb joints throughout their careers
- Several sporting activities have been observed to be associated with the development of osteoarthritis of the hip

What this study adds

- Ex-elite handball players have a higher prevalence of premature osteoarthritis of the hip than age matched controls
- They show passive range of motion and pain level specific to the long term practice of handball

irregularities on the femoral head and the decrease in the JSW can be explained by a mechanical weakening of the bony and cartilaginous structures, reflecting an accumulation of micro-traumatic lesions. Once the process of OA is initiated, the primary functions of joint cartilage are altered and deterioration will not stop.[8]

Considering the hips with OA, the analysis of the passive ROM revealed evidence of joint stiffness in medial rotation and flexion, with the hip amplitude in rotation decreasing with disease aggravation.[33] These amplitude values correlated negatively with the severity of OA. In the handball group, the high values for extension, abduction and lateral rotation may be explained by the frequent repetition of movements specific to the practice of handball.

The study showed few repercussions in terms of pain in the handball players, particularly in those with OA, indicating that the hip OA was well tolerated even with a score of 4 on the Kellgren and Lawrence scale. One explanation for the low rate of symptoms among players with OA may be that these subjects have developed a resistance to pain specific to the elite practice of handball. Indeed, the experience of pain during the career of elite athletes may increase the pain tolerance threshold.[34] Only those movements requiring great amplitude in flexion were sources of functional disturbance, as indicated by the Lequesne and WOMAC functional scores.

We recognise that our study has limitations: it would be interesting to perform a prospective study with elite players to follow the eventual development or progression of the disease; the use of a questionnaire can never be totally valid and a degree of misclassification can occur in the collection of

Table 4	Functional and pain status of the subjects			
	Handball players		**Controls**	
	Healthy (n = 8)	OA (n = 12)	Healthy (n = 34)	OA (n = 5)
Score of Lequesne				
Median (quartile 1, 3)	0 (0, 0)	2 (2, 3)	0 (0, 2)	5 (4, 9)
Range	0–0	1–8	0–2	2–12
WOMAC functional subscale				
Median (quartile 1, 3)	0 (0, 0)	3 (2, 3)	0.5 (0, 1)	6 (5, 6)
Range	0–0	1–7	0–2	3–7
WOMAC pain subscale				
Median (quartile 1, 3)	0 (0, 0)	15 (0, 32)	0 (0, 0)	70 (30, 80)
Range	0–0	0–60	0–0	20–80

OA, Osteoarthritis; WOMAC, Western Ontario and McMaster University.

data; the number of handball players should be increased to strengthen the power of the results. However, this study underlines biological adaptations of the cartilaginous structure to the accumulation of mechanical loads using radiographs, ROM, and indexes.

CONCLUSION

Long term handball practice seems to have an effect on hip ROM and to be associated with the premature development of hip OA. However, the characteristic pain of OA was rarely observed in the handball players. There is sufficient evidence to warrant the implementation of further control measures including the development of preventive measures for young elite handball players as part of an overall risk management process. The use of shoes with special absorbing soles and changes in the schedule of young players would give them a better chance of reducing the effect of the excessive mechanical loads.

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Ethical approval: *x* ray examinations were performed systematically according to French law in the case of polytraumatisms.

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. . . .   **COMMENTARY**   . . . .

The authors of this well written paper have attempted to investigate and describe the passive hip and knee range of motion, the prevalence of radiological hip osteoarthritis, and the degree of hip pain in former elite handball players. The research results on the aetiological factors involved in the development of hip osteoarthritis are sometimes conflicting. Often several factors work together. All the knowledge we can obtain on the primary and secondary prevention of hip osteoarthritis and the associated disabilities is important.

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