



Sports activities after total hip arthroplasty

Martin Krismer

- Performing sports after total hip arthroplasty (THA) may be associated with a risk of
 - Trauma (fracture and dislocation)
 - Shorter implant survival
- There is no proof that trauma occurs more often than in healthy individuals, but sequelae may be more severe.
- Shorter implant survival due to repetitive high contact forces is a fact, due to increased wear. The 15 year survival in highly active patients seems to be around 80%.
- Surgeons can address the needs of active patients by using bearings with low wear rates, and femoral heads up to 36 mm in diameter.
- The data provided in this review may help to fully inform active patients of the risks. The patient has to balance the pros and cons of sports after THA and to decide the best way for themselves.

Keywords: total hip arthroplasty; sports; implant survival; recommendations

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Introduction

In April 2016 I performed a total hip arthroplasty (THA) in one of my former rock climbing partners. Four months later, this patient had a severe climbing accident. A hold broke, and he fell headlong downwards. Fortunately, after a fall of 2 or 3 metres, the trousers of his operated leg were caught by a rock spur, and he was caught upside-down, hanging on his operated hip. This severe accident had no medical consequences, and he continued to climb. For many patients, it is important to continue their sporting activities, and stopping them would mean a considerable loss of lust for life.

The surgeon consulting the patient having a THA is perhaps not a rock climber. He is aware of dislocation and fracture risk as well as survival rates. He feels responsible for his patients, and is also amenable to the law. He would be rather hesitant to give a recommendation to continue rock climbing after THA.

The surgeon wants to base his recommendation on good evidence, but the literature on sports and THA is sparse. There are two main concerns: the risk of dislocation and periprosthetic fracture and survival of the implant. Recently, a Cochrane review¹ looked at the evidence of precautions taken to avoid dislocation after THA. Only three articles of low quality could be detected. Sportsmen are in a different condition from average patients. For example with regard to dislocation, it was shown that weakness of abductor muscles may be one of the most important causes for dislocation.² A sportsman in good shape even performing his sports may be at much less risk of a dislocated hip than elderly people with weak abductors. Bearing in mind hundreds of different sports, with big differences in personal skills, and an important contribution of individual factors, it is a difficult task to establish well-founded knowledge in this area.

This article will deal with dislocation, periprosthetic fracture, implant survival (heat generation, wear, bone quality).

Return to sports

Many patients return to sports without problems. Others do not, because of fear or they are following recommendations of their surgeons. Many resume sports activities after some years, perhaps because they realise they are fit enough and able to do so.

Chatterji et al³ followed 216 patients for two years. THA had a beneficial effect on sports performance. Walking and swimming were resumed within three weeks after operation, tennis after 1.5 and two years. Walking and aqua-aerobics showed an increase, whereas golf and tennis decreased, and jogging was stopped in six out of seven who practised jogging before operation.

In a study of 62 patients,⁴ 29% stopped their activities due to fear of injury, and 26% due to physician recommendation. In 420 patients followed for five years after THA,⁵ only 36% maintained their sports activities immediately after operation, but 50% resumed their activities within five years, and 14% performed sports more than two hours per week. Wylde et al⁶ performed a postal survey with 911 patients after THR and 157 after hip resurfacing. In all, 35% and 64 % were active in sports pre-operatively, and 26%

and 23%, respectively, were unable to return to sports post-operatively, mainly due to pain, inability to do the required movements, medical advice, or fear of damaging the joint. Williams et al⁷ evaluated 736 patients with several questionnaires one year after THA (343), hip resurfacing (82), and other arthroplasty procedures. UCLA score as a measure of activity level increased from 4.5 to 6.3. Pre-operatively, only 17% had a UCLA activity score of seven or more, and at one year post-operatively this increased to 43%.

In a study on jogging,⁸ 33 patients went jogging pre-operatively and 23 post-operatively. After a mean follow-up of five years, no patient complained of pain, and no hip showed loosening.

Lefevre et al⁹ investigated whether judo could be practised after joint replacement. A total of 27 patients had a THA. All patients stopped competitive judo. In total 80% began practising judo again after a mean of four months after surgery. The mean follow-up was nine years. Two revisions due to loosening occurred.

Fouilleron et al¹⁰ followed 40 patients practicing running before hip resurfacing arthroplasty. A total of 92% resumed running, with a mean time devoted to running of three hours per week. In a similar study of 50 patients engaged in high impact activities,¹¹ 82% resumed their sports at a high level after hip resurfacing. Fisher et al¹² studied 117 patients after resurfacing arthroplasty, with a mean age at operation of 54 years. Of these, 87% took part in sporting activities. Preferred sports were golf, swimming, dancing and cycling.

Return to sports is common. The extent is influenced by recommendations and by fear of damaging the artificial joint. The pre-operative activity level plays an important role. Even judo and running are resumed when performed before surgery.

Loads in the hip joint

There is good data on the loads in the hip joint, and their increase during sports (Table 1).

Bergmann et al¹³ in 1999 described a hip prosthesis for *in vivo* measurement of joint force and temperature, and the same authors published in 2001¹⁴ *in vivo* loads in the hip obtained in four patients, 11 to 33 months after implantation. The results showed that loads in the hip joint can by far exceed bodyweight. Later, the same team also published data on stumbling¹⁵ showing that loads up to nine times bodyweight can occur, when several steps are required to regain stability.

Giarmatzis et al¹⁶ calculated the hip loads based on gait laboratory data of 20 patients. Peak loads per bodyweight exceeded those of Bergmann by far. Li et al¹⁷ used gait laboratory data to calculate hip reaction forces in 38 healthy individuals and 15 asymptomatic THA patients.

The asymptomatic THA patients showed comparable values with healthy individuals in the first half of the gait cycle, but 30% lower peak loads at toe-off.

Van den Bogert et al¹⁸ used an accelerometer in nine males and calculated hip forces based on these data. Measurements were also performed in intermediate to expert alpine skiers.

Cleather et al¹⁹ calculated the hip loads in 12 weightlifters based on a motion capture system and a ground-force plate.

The most reliable results can be expected from direct measurement.^{14,15} The results of Giarmatzis et al¹⁶ seem to be overestimated. The maximum peak loads in sports (weight lifting)¹⁹ are in the range of a stumbling, almost falling, patient.¹⁵

Heat generation in artificial hip joints

Friction in the bearing and resulting heat generation may endanger implant survival. Bergmann et al²⁰ measured heat *in vivo* in seven hip prostheses of five patients between ten and 58 months after operation. The peak temperatures in one hip with polyethylene cups rose up to 43.3 °C after an hour of walking (even the rectal temperature rose by 0.7 °C to 37.8 °C), the average peak temperature of all hips after operation was 41.4 °C. In the same patient with bilateral THA and different bearings, the peak temperature was 43.1 °C in the polyethylene cup and 41.4 °C in the alumina ceramic cup. During cycling the average peak force was 45% of the value during walking, and the peak temperatures after cycling were 39.9 °C. Two patients with low peak temperatures had a high body weight but were physically very active. The authors assume that adaptation due to training may increase perfusion rates in soft tissues. Large numbers of load cycles also decrease friction, and this may contribute to lower temperatures.

In a finite element analysis²¹ these data were used to determine whether temperatures can heat up to a critical level. Implants with a cobalt-chromium head and a polyethylene cup are unfavourable and can elevate the temperature in the synovium to more than 46 °C. The temperature in the femur did not exceed the critical temperature of 45 °C. With different materials lower temperatures can be expected. The cup temperature exceeded this threshold only in two models, ceramic-on-ceramic and high friction, and cobalt-chrome on cobalt-chrome and high friction. In the capsule and synovial fluid, only four models did not heat up to the critical threshold of 42 °C: cobalt-chrome stems (due to a high thermal conductivity of 47 W/mK (watts per meter-kelvin) in comparison with 7.2 for titanium stems), having better lubrication or better heat transfer due to head-cup separation, as well as with increased volume of synovial fluid.

Table 1. Average peak loads in percentage of bodyweight in the hip joint during different activities. 100% is the force on the individual due to gravity. 240% means 2.4 times the force due to the individual body mass. Numbers were rounded to 10% steps. The values of Van den Bogert 1999 were estimated from graphs

		Bergmann 2001 ¹⁴	Bergmann 2004 ¹⁵	Van den Bogert 1999 ¹⁸	Cleather 2016 ¹⁹	Giarmatzis 2015 ¹⁶	Li 2014 ¹⁷
		<i>In vivo</i>		Calculated (gait lab or accelerometer)			
Walking	Slow	240%				420%	
	Normal, operated	240%				480%	330%
	Normal, not operated			250%			370%
	Fast	250%				540%	
Running			520%		910%		
Stairs	Up	250%					
	Down	260%					
Standing up		190%					
Sitting down		160%					
Knee bend		140%					
Stumbling			870%				
Weight Lifting	Jumping				550%		
	Landing				600%		
	Push Jerking				780%		
	Jerk Catching				840%		
Alpine skiing	Short steep			520%			
	Short flat			400%			
	Long steep			390%			
	Long flat			290%			
Cross country skiing	Classical			320%			
	Skating			360%			

Damm et al²² measured *in vivo* friction moments during walking in ten patients up to 13 months after operation, and quoted the values at three and 12 months after operation. The gait velocity did not change in the observation period. At three months, peak friction moments for the two extreme values of the gait cycle were 0.17% and 0.23 % BW m (bodyweight metre) respectively, and at 12 months post-operatively 0.11% and 0.17 % BW m. Friction decreased a lot, but with high individual variation, from 100% decreased to 40% increase. This variation may be caused by 'running-in' effects of the THA, influenced by individual activity levels and by increase in synovial fluid viscosity.

Repeated loading of the bearing may lead to critically high temperatures in the synovium and joint capsule. This can be influenced by material selection by the surgeon, choosing bearings with low friction, and stems with high thermal conductivity. There are considerable 'running-in' effects more pronounced in individuals with higher activity levels leading to lower friction and lower joint temperature.

Implant survival

Gschwend et al²³ conducted a comparative trial comparing two cohorts of 50 patients each, ten in each cohort with a bilateral hip, matched for age, sex, height, and bodyweight. One cohort regularly carried out winter sports (alpine skiing and/or cross-county skiing), the other cohort did not. The active cohort performed also other

sports like trekking, cycling and swimming. After ten years, 30 and 27 patients remained, respectively. The skiers had a higher wear rate of 2.1 mm compared with 1.5 mm, and very active patients of 3 mm to 4 mm. At ten years, active patients were more satisfied with the operation (28/30 vs 19/27). In active patients, one cup and one stem were loose, and eight patients had osteolytic spots due to wear. No loosening occurred in the non-active cohort, and osteolysis only in three cases.

Ollivier et al²⁴ retrospectively compared 70 patients engaged in high-impact sports with 140 who had low activity levels, after a minimum follow-up of ten years. The average age was 59 years, and average BMI 25. The mean HHS (Harris hip score) improved from 54 to 88 in active patients, and from 55 to 69 in the low-activity group. Polyethylene wear was higher in the active group, being 1.6 mm versus 0.7 mm, respectively. A total of 14/70 implants in the active group and 9/140 in the low-activity group had implant revision. Survival after 15 years was 80% in the high-impact sports group and 93.5% in the low activity group.

In a study in 34 young patients,²⁵ activity was measured with a questionnaire and a pedometer, and linear wear was measured. Average gait cycles and wear were similar to reported values in older patients. The authors used a polyethylene liner and 22 mm or 28 mm cobalt-chrome or alumina ceramic heads. Mean linear wear rate was 0.16 mm/year. Wear rate did not correlate with activity, but the statistical power of the study was low.

Table 2. Recommendations based on surveys in surgeons categorising different sports in three categories

		Klein 2007 ³⁰	Healy 2008 ³¹	Swanson 2009 ³²	Laursen 2014 ³³
'Low impact'	Walking	☒	☒	☒	
	Swimming	☒	☒	☒	☒
	Golf	☒	☒	☒	☒
	Stairclimbing	☒		☒	
	Aerobics	☒			☒
	Stationary bicycle	☒			☒
	Road cycling	☒	○	☒	☒
	Cross-country skiing	☒	○		☒
	Hiking	☒	○		☒
	Pilates	☒			☒
	Rowing	☒	○		☒
	Dancing	☒	○*		☒
	Bowling	☒	○		☒
	Double tennis	☒	○	☒	☒
	'Intermediate'	Downhill skiing	○	○	○
Snowboarding		○			○
Weightlifting		○	○		☒
Badminton					○
Mountain biking				○**	☒
Canoe/ kayak					☒
'High impact'	Horseback riding		○		☒
	Jogging, running	○	○	○	☒
	Aerobics	○			○
	Single tennis	○	○	○	☒
	Rock climbing		○	☒***	
Contact sports	○	○		○	

☒ Recommended, allowed, unlimited.
 ○ Not recommended, not allowed, discouraged.
 ○ Allowed with experience, with restrictions (eg. tennis only double), occasional.

Contact sports: football, hockey, handball, basketball, baseball, volleyball (intermediate in Healey). Aerobics separated in high and low impact.

*'Square dancing', ** 'Cycling off-road', ***'Climbing'.

Summary

Active patients obviously show higher wear rates associated with a higher risk of osteolysis and implant loosening.

Dislocation

The dislocation rate in the article of Ollivier et al²⁴ mentioned above was 1.4% in the activity group and 1.9% in the low-activity group, with no significant difference. In the above mentioned study of Lefevre et al⁹ no dislocation occurred in 22 patients who returned to judo after THA.

Kostensalo et al²⁶ determined the risk of dislocation in more than 40 000 hips. The rate of revision for dislocation was 1.74% for 28 mm heads, 0.5% for 32 mm and 36 mm heads, and 0.13% for heads larger than 36 mm. In patients younger than 50 years, the risk was 0.5%, and for those older than 50 years greater than 1%. The authors conclude that the low risk of revision for dislocation does not justify using heads larger than 36 mm, which are associated with higher wear.

Summary

Dislocation is not more frequent in active patients. Surgeons can reduce the risk by using heads up to 36 mm diameter.

Peri-prosthetic fracture

In a register study,²⁷ the rate of periprosthetic fracture was 0.9% five years after primary THA (n = 52 136), and 1.7% after ten years. It is lower in males (0.6% and 1.2%) than in females (1.1% and 2.1%). Increased age is associated with a higher fracture risk.

Mc Grory²⁸ reported a rate of 0.4% of femoral fractures in the Mayo Clinic records. Two of these cases occurred during winter sports.

Bedigrew et al²⁹ measured bone mineral density with dual energy x-ray absorptiometry(DEXA) after THA and hip resurfacing at six weeks, six months, one year, and two years. At six months, there was no decrease in bone density in the femoral neck. Owing to increased bone mineral density in most of the Gruen zones also in THA, the authors believe that patients may return to high-impact activities at six months.

Activity may increase bone mineral density. There is no proof that periprosthetic fractures due to accidents of particular sports occur more often in the presence of a THA. However, the sequelae are more severe after THA.

Recommendations

Most recommendations are based on surveys conducted by surgeons in the United States. Klein et al³⁰ conducted a

web questionnaire mainly in members of the American Association of Hip and Knee surgeons (AAHKS) with a 72% response rate. Their results are here categorised as “allowed”, if more than half of the surgeons agreed to allow the particular sport. Healy et al³¹ performed a current concepts review based on a survey sent to members of the Hip Society (unpublished). The intermediate category in the table (©) is either “allowed with experience” or “no consensus”. Swanson et al³² distributed a questionnaire to members of the AAHKS and had similar results.

In Europe, Laursen et al³³ asked all Danish experts (heads of departments) performing more than 100 prostheses implants per year regarding the most popular sports in the Danish 60 to 69 year-old population (Table 2).

Surgeons in a country where legal liability plays an important role are inclined to give cautious recommendations. This may explain the differences between recommendation in the US and in Denmark. Recommendations given in the past are often taken as textbook knowledge and are repeated in the next survey without own considerations.

Many activities were categorised as “low impact”, although they can be practised as low as well as “high impact” activities. There is a need for a better characterisation of some sports.

Sports with a high risk of accidents like downhill skiing or horseback riding are qualified as intermediate. Perhaps sports familiar to surgeons are more likely to be recommended.

The confounders (adaptation to sports, different levels of sport performance), the conceptual extension of some sports (weight-lifting: lifting 5 kg weights vs the 200 kg weights), the liability background and sociological factors (textbook knowledge, preferred sports by surgeons) make recommendations based on surveys difficult.

The main risk in high impact sports after THA is implant loosening due to repetitive high contact loads. The 15-year survival in highly active patients seems to be around 80% for bearings used about 20 years ago. The dislocation and fracture risk is low. Surgeons can address the needs of active patients by using bearings with low wear rates, and heads up to 36 mm in diameter.

AUTHOR INFORMATION

Department of Orthopaedics, Medical University of Innsbruck, Innsbruck, Austria

Correspondence should be sent to: Martin Krismer, Anichstrasse 35, A-6020 Innsbruck, Austria.

Email: martin.krismet@i-med.ac.at

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