

Sports Activity after Total Hip and Knee Arthroplasty

Specific Recommendations Concerning Tennis

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Contents

Abstract	571
1. Results of Total Hip and Knee Arthroplasty after High Activity Levels	573
1.1 Effects of Activity in General	573
1.2 Specific Hip Studies	574
1.3 Specific Knee Studies	574
2. Surgeons' Perspective	575
2.1 General Perspective	575
2.2 Specific Hip Perspective	576
2.3 Specific Knee Perspective	577
3. Patients' Perspective	578
4. Patients' Ability to Return to Sports	579
4.1 General Studies	579
4.2 Specific Hip Studies	579
4.3 Specific Knee Studies	580
5. Discussion	580
6. Conclusions	581

Abstract

Lower extremity total joint arthroplasties are among the most successful operations in orthopaedics. Presently, it appears that some patients wish to not only have general functions restored, but also desire the opportunity to return or continue on a high level of activity. This review summarises the literature concerning athletic activity, and tennis in particular, in relation to lower extremity total joint arthroplasties. Orthopaedic surgeons frequently recommend participation in low-impact sports such as swimming, walking, bicycling, bowling and golf. The patient's return to these recreational activities appears to be without problems. In contrast, there has been a general consensus from surgeons to avoid high-impact sports such as tennis and jogging after total joint arthroplasty, but

there have been numerous studies that reported functional results being compatible with these activity levels. Conflicts emerge with some studies that describe lower survival rates for hip and knee arthroplasty in patients participating in high-impact sports. Most of these studies report that participation in sporting activities following total joint arthroplasty refers to increased polyethylene wear and debris, which could eventually result in implant failure. With recent advances in implant technology and surgical technique, the survival rates for modern prosthetic designs and patients with these high demands are promising. Various studies assessing the association between clinical outcome and participation in tennis did not demonstrate a harmful effect on implant survival rates. Although the majority of these studies do not reflect a true representation of the average patient undergoing total joint arthroplasty, more surgeons are confronted with the patients' desire to continue with sports activity. To optimise results, patients who demand higher levels of activity must be carefully selected, and must have the motivation and drive to optimise their results. In general, all patients should be encouraged to remain physically active to improve general health, maintain good bone quality, and improve implant fixation. There is still a need for prospective, randomised controlled studies concerning high activity and its impact on total joint arthroplasty.

As the number of senior citizens participating in athletic activity increases and more younger patients are undergoing total knee and hip arthroplasty surgeries, orthopaedic surgeons are more commonly being confronted with patients interested in returning to sports activities. The primary goals of lower extremity joint arthroplasty have traditionally been pain relief and restoration of minimal impact activities of daily living, with patients commonly discouraged from participating in high-activity athletics. Based on new patient expectations, it appears that some patients wish to not only have general functions restored, but also desire to increase or continue at a high activity level.

There are few studies specifically analysing participation in athletic activity following standard total hip or knee arthroplasties. The vast majority of these reports outline surgeon advice regarding general activities. Most studies recommend at most, low-impact sports, such as swimming, regular walking, cycling, golfing, hiking or bowling. In contrast,

many orthopaedic surgeons encourage patients to avoid high-impact sports such as basketball, football, soccer, karate, running, racquetball or hockey in an effort to minimise polyethylene wear and prevent aseptic loosening.^[1-7]

The reports and recommendations specifically concerning tennis participation vary. In addition, it is important to understand that tennis can be either a low-impact or high-impact sport, depending on the patient's preference. We view doubles tennis as generally a fairly low-impact sport, whereas, singles tennis can easily exceed intermediate impact levels and be high impact.

Surgeons concerns about participation in sporting activities following total joint arthroplasty usually are based on the increased joint load resulting in augmented implant wear and debris generation, which can lead to periprosthetic osteolysis and eventual prosthetic failure.^[8-10] Schmalzried et al.^[11] evaluated activity levels and polyethylene wear in 37 hip replacements. They showed a positive corre-

lation between higher walking speeds and wear ($p = 0.07$). Kilgus et al.^[12] compared revision rates of total hip arthroplasty patients who chose to participate in high-activity athletics to those without high activities. They found higher revision rates in the more active group compared with the less active group. Another factor against high-activity sports in these patients is that the participation may place the joint implant into extreme ranges of motion, which can lead to a greater risk for dislocation, loosening, or periprosthetic fracture. In summary, the basic premises are that these activities result in increased cyclic loading and other activity-related problems, so that high-activity sports should be avoided. However, there have been various studies in the literature that report no adverse effects of high activity on total hip or knee replacements.^[4,5,13-19] Thus, the controversy of sporting activities after total joint replacement remains a frequently debated topic among orthopaedic surgeons, and now more often has to be addressed because of patient demands.

The purpose of this article is to summarise the existing literature about athletic activity in general, and tennis in particular, in relation to both total hip and knee arthroplasties. In addition, a literature review will attempt to provide an evidenced-based rationale for recommendations for surgeons facing patient's concerns and questions to participate in tennis or any sports after surgery. The authors will approach this topic by analysing outcomes of lower extremity total joint arthroplasty, from a surgeons' point-of-view and from the patients' perspective. We will also examine the ability of patients to resume athletic activity as well as tennis.

1. Results of Total Hip and Knee Arthroplasty after High Activity Levels

Several reports have analysed the outcome of lower extremity total joint arthroplasty after patient participation in sports in general as well as in high-activity athletics. Some studies have examined the

effect of young age and have used this factor as a predictor of outcome with young age patients presumed to have high activity levels. The results of these outcome studies vary and will now be summarised.

1.1 Effects of Activity in General

Many studies focus on the adverse effects of activity after total joint arthroplasty. Schmalzried et al.^[20] reported that up to 500 000 submicron-sized polyethylene particles are released with each step after total knee arthroplasty. These wear particles initiate a cascade of processes eventually leading to periprosthetic osteolysis and aseptic loosening.^[21] Schmalzried et al.^[20] also reported that wear is a function of use.^[11]

In a multicentre study of 1081 total hip arthroplasties, Maloney et al.^[8] revealed that there was a correlation between polyethylene wear rate and patient age. At a minimum follow-up of 5 years (mean follow-up of 81 months), younger patients (<50 years of age) had higher wear rates and a higher risk for having periprosthetic osteolysis. They proposed that the most likely cause for the association between age and wear is patient activity level. Kilgus et al.^[12] analysed cemented surface replacements and cemented stemmed total hip arthroplasties in patients who regularly participate in sporting activities. The authors concluded that more active patients are at twice the risk for revision surgery for aseptic loosening when compared with less active patients. Kim et al.^[22] prospectively analysed 55 patients aged <50 years. The authors determined the prevalence of aseptic loosening, wear and osteolysis at a mean follow-up of 9 years. There was no case of aseptic loosening and six hips showed osteolysis (6%), but the authors were concerned about the particularly high rates of polyethylene wear (43.4 mm/year) in this group of patients. Similar results were found in various other studies.^[23-25] Finally, Gschwend et al.^[26] analysed two

groups of 50 patients each after total hip arthroplasty. The first group did alpine and cross-country skiing, whereas the second group did not participate in any type of winter sports. At a final follow-up of 10 years, the authors found a higher rate of wear in the group participating in winter sports activities.

1.2 Specific Hip Studies

In contrast, some studies have shown positive effects of activity on the outcome of total joint arthroplasty. Dubs et al.^[13] retrospectively analysed 110 patients (136 hips) with total hip arthroplasties. They found an increased incidence of revision due to aseptic loosening in the group of patients that did not participate in athletic activity ($n = 49$) when compared with those with intense sporting activity ($n = 61$). At a mean follow-up of 5.8 years, the authors reported seven revisions in the non-sporting group (14.3%) compared with only one revision in the group participating in sporting activity (1.6%). Similar results were found in two other studies. Von Stempel et al.^[17] reported aseptic loosening rates of total hip arthroplasty of 5% in an active group versus 10% in a non-active group of patients. Widhalm et al.^[18] found component loosening of 18% in the patient group that participated in sports compared with 57% in a group of patients that did not participate in sports after total hip arthroplasty. Utilising survivorship analysis, Cornell and Ranawat^[16] predicted the cumulative rate of success in a series of 101 primary total hips (85 patients) at a mean age of 50 years and at a mean follow-up of 7 years (range 4–13 years). Their analysis predicted an 87.6% success rate at 10-year follow-up. The authors reported no adverse effects on durability of components in younger more active patients.

In a questionnaire-based study of 214 total hip arthroplasties with at least 3-year follow-up, Ritter and Meding^[4] demonstrated that low-impact sports such as walking, golf or bowling had no negative

effect on the clinical outcome of total hip arthroplasties. The authors showed a positive correlation between total activity scores after surgery and the pre-operative range of motion ($p < 0.01$). Additionally, there was a positive correlation between the 6-month ranges of motion and total activity score immediately following surgery ($p < 0.001$). Thus, increased activity in the immediate post-operative period improved outcomes of total hip arthroplasty.

Mont et al.^[14] characterised patients who play tennis after total hip arthroplasty. In their study population of 75 hips, three hips (4%) underwent revision arthroplasty. However, the authors state that the inclusion criteria in their study may self-select for a successful outcome. Because of the selection bias in their study, no conclusion should be drawn concerning revision rates in tennis players.

1.3 Specific Knee Studies

Lavernia et al.^[27] assessed the correlation between activity level, wear rate and length of prosthesis implantation in a study of autopsy retrieved specimens after total knee arthroplasty. At a mean length of implantation of 74 months, the authors found a positive correlation between activity level, length of implantation and wear rates. Mintz et al.^[28] arthroscopically evaluated tibial polyethylene in 33 patients after total knee arthroplasty. The authors demonstrated that component failure occurred predominantly in younger and more active patients. A case control-study by Jones et al.^[29] determined athletic activity as a risk factor for need for revision total knee arthroplasty. The authors looked at 26 patients that had primary total knee arthroplasties followed by revisions and compared them with a control group of 26 patients with total knee arthroplasties who did not have a revision. All patients were telephone interviewed concerning their activity levels post-operatively. Most of the activities were of low impact (swimming, walking). The authors concluded that physical activity is not a risk

factor for revision total knee arthroplasty and that one should encourage patients to remain active after total knee arthroplasty. Diduch et al.^[19] evaluated 114 knee replacements in 88 young and active patients (aged <55 years). At a mean follow-up of 8 years (range 3–18 years) they reported a mean Knee Society Score of 94 points and a mean functional score of 89 points with an overall survival rate of 87% at 18 years. Some of the patients in this study regularly participated in high-impact sports such as tennis and skiing or were engaged in heavy labour such as farming.

In a recent study, Mont et al.^[30] compared radiographic and clinical outcomes of 50 patients engaged in a minimum of 4 years of high-impact activities such as golf, skiing, tennis, cycling or jogging following total knee arthroplasty, to an age- and sex-matched cohort of 50 sedentary patients. At a mean 7-year follow-up, there were two revisions and one clinical failure in each group with no progressive radiolucencies reported. Thus, high-impact activities conferred no difference in outcome at this mid-term follow-up study. The same authors also evaluated 30 total knee replacements in 30 patients aged <50 years at a mean 7-year follow-up (range 60–107 months).^[31] They found excellent or good clinical and radiographic outcome in 29 of 30 patients.

Mont et al.^[15] also analysed patients who played tennis after total knee arthroplasty. Thirty-three tennis players (46 knees) participated in the study. In two out of 46 knees (4%) revision surgery because of polyethylene wear was required at 8 and 11 years. Again, the inclusion criteria were self-selected and, therefore, there was a selection bias.

In summary, many study findings do not allow the reader to draw conclusions whether sports in general or high-impact activity such as singles tennis should be contraindicated after lower extremity total joint arthroplasty. Some studies reported beneficial effects of sports after total joint arthroplasty,

some revealed negative effects such as high wear rates and osteolysis. Nevertheless, there are really no specific studies concerning outcome of total hip and knee arthroplasty after tennis activity in the literature.

2. Surgeons' Perspective

Surgeons generally have mimicked the results of studies concerning the outcome of lower extremity total joint arthroplasty in their patient recommendations. Most surgeons believe that total joint arthroplasty is primarily performed to improve function, pain and quality of life.^[32-34] In the vast majority of patients undergoing total joint arthroplasty, there is no problem in resuming an active lifestyle after the procedure.^[35-38] Moreover, some studies have revealed an increase in athletic activity after total joint arthroplasty.^[5,39,40] However, orthopaedic surgeons typically do not like to see patients resuming full sports activities following total joint arthroplasty. Following some of the literature reviews, surgeons consider athletic activity as a major risk factor for implant failure, especially in the younger, more active patient.^[41] The surgeons' worries predominantly deal with aseptic loosening secondary to intense polyethylene wear and debris in patients participating in athletic activity.^[10,11,20,42,43]

2.1 General Perspective

McGrory et al.^[2] analysed various sport activities and surgeons' recommendations after lower extremity total joint arthroplasty in a questionnaire-based study. The authors sent a questionnaire with a list of 28 common sports to 15 orthopaedic faculty members, 2 adult reconstruction fellows and 13 fifth-year orthopaedic residents. The surgeons were asked whether regular participation in the listed sport activities would be allowed after lower extremity arthroplasty surgery. The majority of the surgeons (>75%) would allow their patients to resume low-impact activities such as swimming, cycling, sailing,

Table I. 1999 The Hip Society consensus recommendations (reproduced from Healy et al.,^[45] by permission of Sage Publications, Inc.)

Activity	Rec.	Rec. with experience	Not rec.
Stationary cycling	Yes		
Croquet	Yes		
Ballroom dancing	Yes		
Golf	Yes		
Horseshoes	Yes		
Shooting	Yes		
Shuffleboard	Yes		
Swimming	Yes		
Doubles tennis	Yes		
Walking	Yes		
Low-impact aerobics		Yes	
Road cycling		Yes	
Bowling		Yes	
Canoeing		Yes	
Hiking		Yes	
Horseback riding		Yes	
Cross-country skiing		Yes	
High-impact aerobics			Yes
Baseball/softball			Yes
Football			Yes
Soccer			Yes
Handball			Yes
Hockey			Yes
Jogging			Yes
Racquetball			Yes
Squash			Yes
Lacrosse			Yes
Gymnastics			Yes
Singles tennis			Yes
Rock climbing			Yes
Basketball			Yes
Volleyball			Yes

Rec. = recommended.

scuba diving, golfing and bowling after total hip and knee arthroplasty. In addition, they would allow their patients to do cross-country skiing after total knee arthroplasty. Kusterand and Stachowiak^[42] demonstrated that increased cyclic loading of the polyethylene inlay causes increased wear and should therefore be avoided. They suggested that

surgeons should concentrate on these patient-based factors and restrict patient activity to avoid osteolysis and aseptic loosening.^[42] Dorr^[44] extensively commented on osteoarthritis, osteotomy, total joint arthroplasty and athletics. The author states that in younger patients the operative procedure should be correlated to patient's lifestyle and desired activity level. The continuation of athletic activity after surgery is reasonable as long as it is not dynamic and does not involve running or jumping. He recommended activities such as swimming, hiking, cycling, walking and golfing. Nicholls et al.^[3] stated that total hip and knee arthroplasty is a successful treatment for the arthritic hip and knee to relieve pain and restore function. However, for the younger, more active, ambitious patient, the authors recommend that athletic participation following index surgery should be limited to low-impact, low-demand and low-duration activities.

2.2 Specific Hip Perspective

Dubs et al.^[13] analysed sporting activity after standard total hip arthroplasty. In a retrospective review of 110 patients, they looked at patients with intense athletic activity and compared the findings with those who did not participate in athletic activity. The authors found no need to prohibit sports, especially with a gradual resumption of sports. They even included high-impact sports such as jogging and tennis in their recommendations. Mont et al.^[14] surveyed 58 tennis players regarding resumption of playing tennis after total hip arthroplasty. At the time of the survey, only eight of the patients' surgeons (14%) allowed this high-impact activity. Twenty surgeons (34%) tolerated doubles play and 30 surgeons (52%) were completely opposed to any type of tennis participation. Healey et al.^[45] surveyed 54 members of The Hip Society regarding their standpoint of participation in athletic activity after total hip arthroplasty. The responses were analysed with a statistical programme and consen-

sus recommendations were proposed. In general, low-impact activities such as ballroom dancing, stationary cycling, golfing, swimming, walking and doubles tennis were allowed. There was a clear consensus that high-impact activities such as ball sports, squash and singles tennis are not recommended after the surgery. A summary of their results is displayed in table I.

2.3 Specific Knee Perspective

Mont et al.^[15] studied patients who resumed playing tennis after total knee arthroplasty. An analysis of questionnaire-collected data revealed that only seven orthopaedic surgeons (21%) approved playing tennis after the procedure. Fifteen surgeons (45%) recommended participation in doubles tennis, whereas 18 surgeons (55%) discouraged the patients in returning to play tennis. In a recent survey of 58 members of The Knee Society, consensus recommendation regarding athletic activity were published.^[45] Recommended activities included bowling, golfing, walking, swimming and dancing. A complete overview of their recommendations is given in table II. Bradbury et al.^[6] reviewed 176 patients concerning participation in sports after total knee arthroplasty. The authors concluded that it is reasonable to allow patients to return to low-impact activities such as swimming, cycling and walking. Despite new prostheses and refined surgical techniques, they recommended avoiding high-impact activities such as tennis.

In summary, there is little in the literature concerning concrete surgeon recommendations regarding athletic activity after lower extremity total joint arthroplasty. Most surgeons discourage patients from participating in sports.^[7,10,24] However, some reports actually encourage patients to resume athletic activity for general health and bone quality improvement.^[35,36] In general, for patients who would like to continue with their recreational activities, the

Table II. 1999 The Knee Society consensus recommendations (reproduced from Healy et al.,^[45] by permission of Sage Publications, Inc.)

Activity	Rec.	Rec. with experience	Not rec.
Stationary cycling	Yes		
Croquet	Yes		
Ballroom dancing	Yes		
Golf	Yes		
Horseshoes	Yes		
Shooting	Yes		
Shuffleboard	Yes		
Swimming	Yes		
Doubles tennis	Yes		
Walking	Yes		
Low-impact aerobics	Yes		
Horseback riding	Yes		
Bowling	Yes		
Road cycling		Yes	
Speed walking		Yes	
Canoeing		Yes	
Hiking		Yes	
Tennis		Yes	
Cross-country skiing		Yes	
Rowing		Yes	
Ice skating		Yes	
Weight machines		Yes	
Stationary skiing		Yes	
Volleyball			Yes
Football			Yes
Soccer			Yes
Handball			Yes
Hockey			Yes
Jogging			Yes
Racquetball			Yes
Squash			Yes
Lacrosse			Yes
Gymnastics			Yes
Singles tennis			Yes
Rock climbing			Yes
Basketball			Yes

Rec. = recommended.

majority of orthopaedic surgeons would recommend the avoidance of high-impact activities.

3. Patients' Perspective

Between 1990 and 2002, the rate of primary total hip arthroplasties increased by 46% and the rate of primary total knee arthroplasties increased by approximately 150% in the US.^[46] Much of this increase was due to a younger patient population undergoing total joint arthroplasty. With this increased demand for total joint arthroplasties, the ability to participate in athletic activity has become one of the biggest concerns of patients undergoing these procedures.^[47] The younger, and in general, more active patients have greater expectations.^[3]

Only few reports focus on these patient concerns and expectations to return to athletic activity. Several reports have focused on the importance of activity and its beneficial effects on medical problems such as obesity, hypertension, diabetes mellitus, anxiety, depression, osteoporosis, low back pain and coronary artery disease.^[35,36,48] However, the problem of returning to athletics and what type of activity remain key questions among patients of any age group. Media coverage of professional athletes returning to high-level sports after total joint arthroplasty and medical advertisement campaigns frequently imply unrealistic outcomes for the ordinary patient. These falsely raised patient expectations sometimes may lead to patient dissatisfaction after total joint arthroplasty.

The historical patient's expectations concerning lower extremity total joint arthroplasty were simple pain relief and restoration of general function.^[49,50] Moran et al.^[51] used a questionnaire-based study of 370 patients to assess patient worries before total hip and knee arthroplasty. The authors found cancellation of surgery, no relief in pain, risk of amputation, risk of infection and risk of dying in surgery to be the major concerns. Further statistically relevant concerns were stiffness, risk of dislocation, ability to use stairs, falling, joint replacement wearing out, bathing/washing ability, leg length discrepancy and post-operative pain. The study did not address recre-

ational activities. Trousdale et al.^[47] prospectively surveyed 236 patients regarding concerns prior to total hip or knee arthroplasty. They found that pain after surgery, length of recovery, ability to walk, ability to return to recreational activities, ability to walk stairs, risk of getting AIDS from a transfusion, risk of infection and joint replacement wearing, as the main concerns in their patient population. In addition, hip patients were found to worry more about dislocation, continuation of sexual activity and leg length discrepancy; whereas knee patients concerns were the ability to use steps. Macario et al.^[52] analysed 48 patients considering undergoing total hip and knee arthroplasty regarding their concerns prior to surgery. The patients were asked to complete a survey with 30 questions and rate the importance of each question. The impact of the surgery to care for themselves, the ability to walk normally again, pain relief and post-operative pain were most important concerns of the patients. Again, this study did not address patient concerns regarding athletic activity after surgery.

Concerning tennis in particular, Mont et al.^[14] submitted a questionnaire to regional United States Tennis Association (USTA) members to identify patients who had undergone total hip replacement surgery. Fifty-eight members (75 hips) had total hip replacement surgery at a mean age of 62 years (range 42–77 years). All respondents stated a desire to resume or increase participation in tennis after surgery. In fact, for most of these patients, the primary reason for getting a total hip replacement was to resume playing tennis.

In a survey of 33 members of the USTA who had undergone 46 total knee replacements, Mont et al.^[15] analysed the functional abilities and degree of satisfaction of the respondents. The questionnaires solicited information regarding clinical data, general and specific questions on tennis. The patients underwent arthroplasty at a mean age of 57 years (range 30–79 years) and the questionnaire was completed at a

mean 7 years post-operative (range 2–18 years). This study demonstrated that it is the patients' wish to participate in singles tennis against the advice of their orthopaedic surgeons.

In summary, historically patients have been concerned with returning to activities of daily living after lower extremity total joint arthroplasty. However, for many patients, the pain and the decrease in activity affecting daily living still continue to be the driving forces in proceeding of total joint arthroplasty surgery. More recently, questionnaire-based studies have revealed an increased interest in returning to athletic activity and high-activity sports,^[47] which have been specifically exemplified to tennis by two studies of participation in hip and knee patients.^[14,15]

4. Patients' Ability to Return to Sports

There is little in the literature concerning patient ability to participate in various sports after lower extremity total joint arthroplasty. Sections 4.1–4.3 summarise sports activity in general after total hip and knee arthroplasty. Two studies concerning tennis after lower extremity arthroplasty are then specifically discussed.

4.1 General Studies

Huch et al.^[53] analysed sports activities performed pre-operatively and 5 years post-operatively in a multicentre study with 420 total hip and knee arthroplasties. Their patient population in this study consisted of 221 women and 199 men who had a mean age of 60 years. Thirty-six percent of the patients undergoing total hip arthroplasty participated in athletic activity prior to index surgery and the number of participation increased from 36% pre-operatively to 52% post-operatively in hip patients. In the cohort of patients who had undergone knee replacement, the number of participants in sports declined from 42% pre-operatively to 34% post-operatively. The authors proposed that one of the

reasons for the better results in the hip cohort was less pain. Approximately 9% of their hip patients reported pain post-operatively and 16% of the knee patients complained of persistent pain in the replaced joint. Mallon and Callaghan^[54] studied active golfers following total hip and knee arthroplasty. Most of the patients remained active golfers with no significant increase in symptoms or implant failure. Patients after total hip arthroplasty had a mild ache in the hip and knee region while playing golf, whereas patients with total knee arthroplasty had slightly more pain after golfing.

4.2 Specific Hip Studies

Visuri and Honkanen^[5] retrospectively interviewed 539 patients with a mean age of 64 years and a mean follow-up of 4.2 years concerning post-operative involvement in regular recreational activities after total hip arthroplasty. They reported an increase in the number of patients who participated in regular recreational activity following total joint replacement surgery. Prior to total hip arthroplasty, 439 patients (81%) did not participate in recreational activities. This number decreased to 173 patients (32%) who did not participate in sports post-operatively. In addition, the authors showed an overall increase in the number of patients participating in several low-impact activities such as walking, cycling, swimming and skiing. Chatterji et al.^[39] surveyed 235 total hip arthroplasties 1 or 2 years after index surgery, specifically asking how the arthroplasty had affected the patient's athletic activity. The number of patients participating in athletic activity increased from 188 pre-operatively to 196 post-operatively. Moreover, the majority of patients stated that the arthroplasty had a beneficial effect on their activity. Although the total number of sports activities decreased from 434 pre-operatively to 382 post-operatively, there have been only five activities where the authors reported a significant change from pre-operatively compared with post-operatively.

The participation in sports such as walking ($p < 0.0001$) and aqua aerobics ($p = 0.002$) increased, whereas patients stopped participating in golf ($p = 0.005$), tennis ($p = 0.01$) and jogging ($p = 0.01$). A single case report by Peters^[55] describes a 69-year-old patient who received bilateral total hip arthroplasties and resumed with his recreational activities (walking, mountaineering). The patient was particularly experienced in high-altitude mountaineering (>4000m) and after having bilateral total hip arthroplasties, the patient was able to return to mountaineering at very high, even professional levels. Ritter and Meding^[4] reported an overall decrease in the number of patients participating in athletic activity following total hip arthroplasty by 27% (164–119 patients). This might reflect the surgeons' conservative recommendations to not participate in sports following total hip arthroplasty surgery.

In the questionnaire study of USTA members, patients returned to competitive play at a mean of 6.7 months (range 1–12 months) after hip surgery.^[14] At the time of the survey, the patients' mean National Tennis Rating Program (NTRP) level was 4.12 (range 1–7) compared with 4.25 before the onset of symptoms. This represented a near full return to competitive performance post-operatively, which was sustained through the 8-year follow-up. All patients reported an improvement in most mobility parameters assessed, with a slight loss in court speed. Various components of the patients' game such as shifting weight in the forehand, backhand, volley, serve, follow-through in strokes, and the ability to move side to side, or forward to serve a volley significantly improved after total hip arthroplasty. Of the 58 patients, 18 (31%) had some pain and stiffness 1 year after hip arthroplasty compared with nine patients (16%) having pain relief at the time of the survey. Although this cohort of patients is not representative of the general population, it illustrates the divergence of surgeon and

patient views concerning the participation in athletic activities after total hip arthroplasty.

4.3 Specific Knee Studies

Bradbury et al.^[6] compared pre- and post-operative physical activity of 160 patients after total knee arthroplasty. The mean age was 68 years (range 27–87 years) and the mean follow-up 5 years (range 3–7 years). Of the 79 patients who participated in sporting activity prior to surgery, 51 patients (65%) returned to sports following surgery and 8 of 23 patients previously inactive started participation in sports following surgery. Bock et al.^[37] analysed the extent of patient activity after total knee replacement. In this study, 167 patients were asked to fill out a questionnaire about their physical activity pre-operatively and post-operatively. The mean age at index surgery was 55 years (range 21–65 years) and at the time of follow-up 63 years (range 24–78 years). The pre-operative participation activity was 80.4%, which was reduced to 75.4% post-operatively.

In the USTA tennis survey after total knee arthroplasty, patients reported a return to competitive play at a mean of 5.9 months post-operative (range 1–10 months).^[15] Patients' mean NTRP ratings were 4.26 (range 1–7 years) post-operative compared with a mean 4.35 (range 1–7 years) rating before the onset of symptoms. This reflects a near return to pre-symptomatic function and ability in this cohort of patients. While all patients had severe pain or stiffness prior to surgery, only 12% (4 of 33) had pain or stiffness at the time of survey.

5. Discussion

The literature regarding participation in tennis after total hip or knee arthroplasty is extremely limited. Although many reports focus on patient outcomes in general, conflicts emerge in studies that describe survival rates for hip and knee arthroplasty in patients participating in high-impact sports. In the

absence of a clear consensus in the literature about survival rates of total hip and total knee replacements following participation in tennis and high-impact activity, there is a need for prospective, randomised controlled studies. The risks and benefits of exercise after joint replacement have been well described.

Reports often do not reflect a true representation of the average patient undergoing total joint replacement. Although the majority of these articles did not specifically focus on tennis after total knee replacement, but on all high-level activities, they reflect the improved survivability of modern prostheses in active patients. Some of these studies included a small number of patients specifically involved in tennis.^[6,14,15,19,30,31,53] The patients in various studies showed no harmful association between short-term outcome and participation in tennis. However, long-term studies are missing to understand the effects of tennis on total hip and knee arthroplasty.

As people increasingly wish to engage in high-impact activities, the burden of the surgeon to establish expectations congruent with patient wishes becomes more important. It is, therefore, the authors recommendation that patients be advised that they can participate in sports post-operatively if they wish, with the understanding that involvement in such activity may render them more likely to sustain post-operative complications such as loosening, fracture and/or dislocation. Factors such as wear, joint loading, type of prosthesis and athletic intensity must be taken into account before recommending sports activity after total joint arthroplasty.

Newer prosthetic designs, advanced surgical techniques and improved surgeon skills are becoming a critical part of the decision-making process. Iorio et al.^[56] reported that pre-operative demand matching is an excellent indicator of patient activity post-operatively. Demand matching may be used to stratify patient activities following total joint replacement surgery and, therefore, should be includ-

ed in choosing the type of prosthesis and the surgical technique. It is every surgeon's obligation to identify patients' expectations, and to frankly discuss functional limits and possible outcomes of total joint arthroplasty with each patient, individually.

Many reports focus on the general benefits of returning to low-impact activity following total joint replacement.^[6,7,35,36] The return to recreational activity appears to be no problem for the majority of patients, whereas the return to high-impact sports remains a privilege of the younger and experienced patient. Patients who have participated in these athletic activities are more likely to return to these activities. The authors think that it is mandatory for the patient to strengthen the muscles around the joint before they return to full activity. Dubs et al.^[13] recommended a biphasic approach to rehabilitation. The first 6 months post-operatively should focus on rehabilitation, which involves mobility and strengthening exercises. During this phase, they recommend low-impact activities such as swimming, cycling and rowing. Once the muscles of the hip are adequately strengthened, they recommend a return to higher impact sports such as tennis, cross-country skiing and hiking. The concept of muscles sharing loads across joints and perhaps protecting joints has not yet been fully clarified in the literature. However, we agree with the approach of Dubs et al.^[13] and recommend extensive lower extremity rehabilitation before returning to high-activity sports after total knee and hip arthroplasty.

6. Conclusions

General recommendations to all patients regarding returning to high-activity sports after lower extremity total joint arthroplasty surgery should be avoided. We believe that giving out a recommendation for returning to high-activity is an individual process. It takes into account multiple factors such as patient age, type of prosthesis, underlying diseases, comorbidities, athletic experience, and extent of

efforts and willingness to undergo rehabilitation. We also think it is appropriate to resume tennis after an intense rehabilitation protocol.

The outcome of total knee and hip arthroplasties has been reported with functional results being compatible with high athletic activity levels. This is encouraging for tennis players with total joint arthroplasties. More data will be following in the future concerning the effects of tennis on long-term clinical and radiographic outcome.

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