Thieme

Sport after Knee Replacement Surgery – a Review of Sport Habits and Key Surgical Aspects

Sport mit Knieprothese – Wieviel Sport ist möglich und was gilt es zu beachten ?

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ABSTRACT

As an increasing number of younger patients are undergoing total knee replacement (TKR) surgery, many wish to participate in sport, but still expect that the implant will survive for a extended period. Most of the current literature shows that patients predominantly participate in low impact activities, both before and after surgery. A few studies show that with appropriate previous experience, high-impact sports are possible and might not result in increased implant failure rates. These include a decrease in point loads on the polyethylene by using more conforming bearing surfaces, avoidance of varus component alignment to minimise stresses at the implant bone interface and avoiding patella resurfacing to facilitate activities in deep knee flexion.

A TKR is no longer an absolute contraindication for higher impact activities such as golf, tennis and ski. What is more important than implant specific factors seem to be patient specific factors, including preoperative activity level, and preoperative sport skills.

The current review paper reports on the current sport habits of TKR patients, analyses biomechanical loads on the knee during different sport activities and reports on implant selection and technical considerations for the active patient undergoing TKR.

ZUSAMMENFASSUNG

Mit dem demografischen Wandel der Patientenpopulation, die einen Kniegelenkersatz erhält, verändern sich die Ansprüche der Patienten. Jüngere Patienten möchten sich nach Implantation einer Knietotalendoprothese (K-TEP) sportlich betätigen und zählen auf die Langlebigkeit des Implantates. Die Literatur zeigt, dass Patienten sowohl prä- als auch postoperativ vorwiegend Sportarten der Kategorie Low Impact ausüben. Ein gewisser Prozentsatz praktiziert mit entsprechender Vorerfahrung auch High-Impact-Sportarten. In der operativen Versorgung kann durch konforme Implantate die Punktbelastung der Polyethylenoberfläche verringert werden, durch eine adäquate Komponentenausrichtung erhöhter Stress an der medialen Knochen-Implantat-Schnittstelle vermieden und durch die Vermeidung eines Retropatellarersatzes eine stärkere Belastung in tiefer Kniebeuge ermöglicht werden.

Eine K-TEP sollte heutzutage kein absolutes Hindernis für High-Impact-Sportarten wie Tennis, Golf oder Skifahren sein.

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Viel mehr als implantatspezifische Faktoren scheinen jedoch patientenspezifische Faktoren ausschlaggebend zu sein, insbesondere das präoperative Aktivitätslevel und die präoperativen Sportgewohnheiten. Die vorliegende Übersichtsarbeit gibt Einblick in das tatsächliche Sportverhalten von K-TEP-Patienten, beschreibt die biomechanischen Belastungsmuster am Kniegelenk bei diversen Sportarten und fasst die wichtigsten Aspekte in der Versorgung von sportlich aktiven Patienten mit einer K-TEP zusammen.

Introduction

Physical activity is part of a healthy lifestyle and has a positive impact on quality of life [1, 2]. Many patients still aspire to engage in sports after undergoing a total knee arthroplasty (TKA) [2, 3]. Meeting this expectation is a key determinant of patient satisfaction [4]. Estimates anticipate a surge in TKAs in younger patients [5]. In 2021, 36.2 % of all TKAs performed in Germany involved patients under 65 [6]. As the age of the patients decreases, this results in increased demands regarding post-operative load-bearing capacity of the joint and long-term implant survival [7]. This raises questions about what is a sensible and realistic level of physical activity that may be achieved after a TKA. The most important determinants are patient-specific factors such as preoperative exercise habits, general fitness level, physical constitution, and concomitant diseases [2]. There are also implant-specific factors to consider, such as the congruence of the joint surfaces, and the joint alignment. Advice from the patient's physician is another influential factor [8, 9]. Initially, expert advice was very restrictive with respect to the practice of sports after a TKA, due to the association with onset of aseptic loosening and polyethylene wear [2]. A survey conducted by the German Working Group for Endoprosthetics (Arbeitsgemeinschaft für Endoprothetik, AE) found that 36.6 % of the physicians who responded still do not recommend engaging in high-impact sports [10]. This is despite several individual studies which show that implants can tolerate a higher level of physical activity, and that sporting activity is not necessarily associated with an increased likelihood of revision [8, 11, 12, 13, 14].

Given that the TKA patient population is becoming increasingly younger, the issue of long-term implant survival is particularly pertinent in this patient group. To date, AE members do not report any distinct preferences concerning the surgical access route, implant design, or joint alignment in TKA treatments of athletically active patients [10]. The patients' athletic objectives should be included in preoperative planning, since activities such as jogging, tennis, or golf exert a different stress on knee joint implants than sports exercises involving extreme flexion.

Method

This review aims:

1. to summarise the level of physical activity and current sports habits of TKA patients,
2. to describe the biomechanical properties as well as the extent of knee joint implant loads exerted by different sports, and
3. to explore and critically discuss the correlation between TKA joint alignment and sports activity.

A systematic PubMed literature search was performed using the search terms 'sport', 'physical activity', 'total knee replacement', 'return to sports', 'impact', 'alignment', 'load', 'clinical outcome', 'functional outcome', 'revision', and 'survival'. In this study we consider the most recent meta-analyses and reviews.

Knee Arthroplasty and Sports

In 1999, the Knee Society recommended the following types of sports after a TKA: low-impact aerobics, exercising on a bicycle ergometer, croquet, classical dance, jazz and square dancing, swimming, walking, and golf [2]. For patients with appropriate previous experience, sports such as cycling, hiking, rowing, skiing, doubles tennis, and weight training were also recommended [2]. Conversely, various ball sports (handball, basketball, soccer, baseball, softball, etc.,) as well as field hockey, jogging, squash, lacrosse, gymnastics, and tennis were not advised [2]. This classification was based on a survey of 112 arthroplasty specialists from the Knee Society [2]. These basic recommendations were slightly modified in 2005, and reflect the current activity patterns reported in the literature for TKA and unicondylar knee arthroplasty patients [15].

Levels of Physical Activity, Participation in Sports, and Return to Sports of TKA Patients

The literature shows a strong correlation between preoperative and postoperative physical activity levels [8, 16]. Between 29.3 % and 100 % of all TKA patients engaged in sporting activities before surgery, and between 21.3 % and 100 % do so postoperatively [9, 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27]. Most patients engaged in low-impact sports prior to surgery, with only a small percentage engaging in high-impact sports [8, 16]. A study by Crawford et al. showed that only 5.4 % of their patients reported an activity level of 8 or more, based on the University of California, Los Angeles (UCLA) scoring system. This corresponds to the regular practice of what are referred to as intermediate sports, such as bowling or golf [11]. Most patients have an activity level of UCLA ≤ 6, and predominantly pursue low-impact sports. Walking, cycling, and swimming are the most popular forms of sport among TKA patients [8, 11, 16, 28]. In a meta-analysis by Hanreich et al., all TKA patients included in the study had a UCLA score of < 8 prior to as well as after surgery [16]. This meta-analysis also showed that patients' postoperative activity levels either remained the same or improved slightly [16]. Patients aged under 55 showed a greater increase in their level of physical activity [16]. In general, the rate of return to sport after TKA mainly varies between 60 % and 90 % [8, 14, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27]. Sports habits do not generally change significantly at a more advanced

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age [29]. One study specifically compared patients with unicondylar knee arthroplasties vs. TKAs vs. patellofemoral replacements (PFE). Unicondylar knee arthroplasty patients had higher postoperative activity scores, but this patient group already had higher preoperative scores [8, 30]. The meta-analysis by Witjes et al. suggests that unicondylar knee arthroplasty patients return to sports at higher rates. The study by Panzram et al., for example, noted a return rate of 100 % at five years after an uncemented unicondylar knee arthroplasty [29]. Here, too, patients favoured low-impact sports both preoperatively and postoperatively. Of the already low percentage of patients who engaged in high-impact sports preoperatively, less than 50 % returned to these sports (volleyball, tennis, soccer, skiing, or jogging) after surgery [29]. Based on the current literature, unicondylar knee arthroplasty patients do not show a significantly greater increase in level of physical activity than TKA patients [8, 20, 30]. The vast majority of all patient groups demonstrated an activity level equivalent to the practice of low-impact sports, irrespective of the surgical approach [8, 16, 30, 31]. In fact, the type of surgery appears to be less predictive of the level of activity post-surgery than the patient's sporting behaviour prior to surgery or before the onset of osteoarthritis affecting the knee joint [30, 32]. It remains unclear whether unicondylar knee arthroplasties are associated with higher revision rates due to greater physical strain [33]. According to the 2021 Annual Report of the German Arthroplasty Registry (Endoprothesen Register Deutschland, EPRD), the probability of a unicondylar knee arthroplasty revision is twice that of a TKA revision [6]. However, the underlying contribution of specific sports activities to this figure remains to be clarified.

High-Impact Sports

The percentage of TKA patients who engage in high-impact sports is generally low [11, 16, 20, 34]. Nevertheless, several studies demonstrate that, given appropriate prior experience, a TKA does not preclude the practice of these types of sports. The study by Mont et al., involved a highly active cohort of patients who practised high-impact sports at an intensive level (4 times per week or 3.5-hour sessions). Patients who jogged, skied, played tennis, racquetball, squash, and basketball had good clinical outcomes at the 4-year follow-up [35]. Only one patient who jogged regularly underwent revision surgery due to loosening. Patients were all fitted with cruciate retaining (CR) systems and had a mean age of 66 years. However, the study population only comprised 31 patients (33 TKAs), and there was no long-term follow-up [35]. In a study of 200 patients (235 TKAs) by Hepperger et al. [18], sports activity after TKA continued to reflect the patients' preoperative level of activity. These patients engaged in high-impact sports such as hiking and skiing. However, this study also has a very short follow-up period of just two years [18]. The study by Vielgut et al., with a 14.9-year follow-up, found that 16.7 % of patients practised high-impact sports such as ball sports, jogging, and squash, with subsequent studies demonstrating that a small proportion of patients also played tennis and skied [19, 20, 36].

While the authors unconditionally approve of high-impact sports such as tennis, golf, and skiing even after total knee arthroplasty, we continue to advise against high-impact sports such as jogging and basketball. With the appropriate expertise, we believe a return to some high-impact sports is also conceivable. Short-term study results with up to four years of follow-up do not indicate any adverse clinical outcomes [16]. There are, however, no long-term results which completely support the theory that it is safe to engage in high-impact sports after a TKA. The impact of a high level of activity on long-term arthroplasty survival outcomes remains to be investigated. Any future studies on this topic must also take into account demographic factors, as well as patient weight, and implant design.

Biomechanics: Which Sports Stress the Knee Joint Most

Walking, Cycling

Knee joint alignment is a significant determinant in mediolateral tibiofemoral load distribution [37]. When walking on level ground, peak loads of up to 201 % of body weight (BWT) are measured at the medial tibial plateau [38]. With a neutral joint alignment, the medial joint compartment takes up to 70 % of the total load during walking, [38] while any further deviation in the varus or valgus direction of more than 3° is associated with a significant increase in medial and lateral joint compartment loads [37]. Peak loads start to increase significantly at higher walking speeds ("power walking"), and even more so when climbing stairs [39] or jogging [40].

The lowest load values are measured during cycling. The load on the knee joint under moderate conditions (60 W 40 rpm) on an ergometer is significantly lower than during walking [41], with peak loads averaging only 119 % of body weight [41]. Having the seat raised to a suitably high position is considered to be an additional protective factor [42].

Climbing Stairs and Deep Squats

As a general rule, current conventional TKAs allow flexion of up to 120° [43]. Biomechanical studies show that starting from just 40° flexion, the load on the knee increases to 3.5 times the person's body weight [44]. The axial load when climbing stairs is comparable to the axial load when walking, and when descending stairs it reaches peak loads of up to 3.5 times the person's body weight [39].

Some sports activities require a high degree of mobility. However, increased flexion during exercise (StairMaster or leg press with half body weight) is also associated with significantly higher tibial component peak loads [40]. From 40 degrees of flexion, the knee and specifically the patella are subjected to considerably higher loads (≥ 3.5 times the person's body weight) [44]. This should be taken into consideration for exercises that involve extreme flexion, and is also an issue with exercises such as leg presses or quadricep extensions. It is advisable to limit flexion to a maximum of 40 degrees during these types of activities to avoid subjecting the knee joint to peak loads.

Tennis, Jogging, Golf

Tennis and jogging both increase load on the knee joint (≥ 4 times BWT) [40]. Consequently, neither of these sports are particularly recommended in the literature [2]. Although golf is generally clas-

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sified as a low-impact sport [15], comparatively high tibial load values (> 4 times BWT) have been measured when playing golf [40]. However, the number of peak loads in golf is much lower than in tennis or jogging, for example (number of golf swings vs. number of steps) [40]. Jogging is characterised by repetitive peak loads, and in tennis the knee joint is exposed to abrupt changes in direction, requiring particularly good stability [40].

Flexion

Studies demonstrate a correlation between flexion and the rolling motion of the femoral condyles. According to Sharma et al., the post-implantation position of the condyles in conventional posterior-stabilised (PS) and CR systems is a key factor affecting range of motion [44]. The condyles of patients with a high degree of flexion (110–130°) were significantly more posterior than those of patients with a lower degree of flexion [44, 45]. Similarly, the paper by Lynch et al. shows that CR systems with mobile bearings and PS systems with fixed bearings achieved significantly higher flexion values than CR systems with fixed bearings [43]. The authors attributed this to differences in the movement and position of the femoral condyles. An additional factor that should also be considered in terms of loading during deep flexion is retropatellar replacement. The EPRD's 2021 annual report states that 11.8 % of all TKA patients also had a retropatellar replacement [6]. This percentage has increased over the past few years and is largely dependent on the treatment standard of individual hospitals [6]. Increased flexion following a retropatellar replacement can lead to significantly higher peak loads on the patella. This is why the senior author of the current review recommends exercising caution when performing fitness exercises such as squats, leg presses, curls, or lifting heavy weights, or else, where appropriate, dispensing with the patella replacement altogether.

Knee Joint Alignment

Currently available studies, which also include a meta-analysis, show no difference in outcomes for kinematically vs. mechanically aligned TKAs [46, 47, 48, 49, 50]. A neutral load-bearing axis was found to be associated with an uncomplicated return to sport and no increased incidence of component failure or wear [30, 51]. Extreme deviations of the load-bearing axis in the varus or valgus direction appear to be the primary problem. The associated asymmetric loading during intensive sporting activity could be detrimental to long-term arthroplasty survival [37, 38]. Nonphysiological load distributions at the bone–implant interface as a result of varus alignment [52] may increase polyethylene wear, particularly in young, active patients, thereby leading to aseptic loosening in the long term [53, 54]. However, there is a lack of studies with long-term follow-up that explicitly examine the association between athletic activity, joint alignment, and revision probability.

Since biomechanical studies support a correlation between peak loads and component alignment, a conventional, mechanical joint alignment (90°) or a modified kinematic joint alignment with up to a maximum of 3 degrees of varus may be advantageous for heavy axial loads (e. g., squats or hard physical labour) [37, 38, 52]. A mechanically aligned joint gives a more even load distribution [37]. The senior author always strives to establish a neutral leg axis in athletically active patients in order to avoid the disadvantages of asymmetrical loading.

The alignment of the joint, the design of the implant, and the associated position of the condyles all affect the extent of loading during flexion [43, 44, 45]. When performing a deep squat, patients with kinematically aligned joints exhibit higher peak loads (> 5 times BWT) than patients with a neutral (mechanical) joint alignment (4 times BWT) [55]. Implants with a congruent or ultracongruent design have lower contact loads than less congruent designs [55].

Implant Fixations

To date, cemented implants are the gold standard [56, 57, 58]. The ERPD's 2021 annual report indicates that 94.3 % of all primary TKAs were cemented [6]. Aseptic loosening remains one of the most common reasons for TKA revision [59], accounting for 23.4 % of all revision operations [6]. Revisions are more prevalent in the 65–84 age group and tend to affect men more than women [6]. Several individual studies do, however, report good results and good arthroplasty survival for uncemented implants, which may be particularly relevant for younger and more athletically active patients. Uncemented fixation allows components to be anchored to the bone in a more durable and robust manner [56, 57, 58, 60, 61] (▶ **Table 1**).

▶**Table 1** Summary of the most important factors in the planning and positioning of knee implants in athletically active patients.

Important factors
▪ Alignment ▪ Contact surface ▪ Patella replacement ▪ Fixation

Personal Experience of the Senior Author

Ultimately, how all the different types of loading actually affect a TKA is not fully understood and requires further study. Results of the previously mentioned studies provide a framework for individual surgeons to adapt their personal recommendations. The following paragraph reflects the senior author's personal views on this subject.

In general, the senior author recommends avoiding strengthening quadriceps using heavy weights in the gym. Since over 90 % of knee arthroplasties performed by the senior author involve retropatellar replacements, he considers loading during deep flexion to be particularly detrimental. In recent years he has taken to adapting implant choices to meet the needs of patients who plan to engage in more vigorous physical activity, such as weight training at the gym or playing tennis. In order to increase the congruence of the tibiofemoral contact surface and thus increase the stability and the size of the contact surface, in his own practice, the senior author often uses CR implants with an ultracongruent polyethy-

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lene insert for these patients [55]. To some extent, this also applies to the somewhat more congruent PS designs. Both designs usually involve resection of the posterior cruciate ligament. However, peak loads during sports seem largely unavoidable, even with the classic flat tibial replacement of an implant which preserves the posterior cruciate ligament. In 2020 there was an increase in the use of PS implants (19.2%) in Germany in [6], although the most frequently used system is still the CR design (43.4%) [6]. Only limited data are available on this question. It may be that a PS design with its slightly better range of motion may have advantages for sports such as yoga or ballet, while more congruent designs are preferable for heavier loading during flexion (tennis, fitness).

A TKA has an expected survival of up to 20 years. There are, however, few available studies that focus on analysing revision probability or long-term implant survival. As a case in point, the 2021 annual report of the EPRD considers a period of just six years [6]. Only targeted, long-term follow-up studies will determine the effect of sports activities on implant survival and resolve whether uncemented fixation provides an advantage in this respect. Given his positive experiences with cemented fixation, the senior author only uses uncemented fixation in individual cases.

It is also important to consider other patient-specific factors such as age, BMI, and concomitant diseases, all of which are factors that contribute to reduced implant survival according to the EPRD [6]. According to the senior author, patient weight in particular is a key factor in this regard. Overweight individuals would be well advised to avoid higher impact sports (e. g., tennis) and focus on improving general fitness (e. g., cycling, Nordic skiing, elliptical training) and losing weight.

Summary

Studies have shown that resuming physical activity is very important for patients overall, and leads to increased patient satisfaction [32]. In this context, TKA patients predominantly engage in low-impact sports, with only a small percentage reaching high levels of activity [11, 16, 30, 62]. In any case, most patients had already given up more intensive sporting activity following the onset of osteoarthritis symptoms [29, 30]. Furthermore, age is also an important factor affecting the interest in and intensity of sporting activities. Based on a study from the Robert Koch Institute (RKI) on the health of adults in Germany (DEGS), the average level of physical activity among the general population significantly decreases from the age of 70 onwards [63]. Considering that in 2018, 65.3% of all arthroplasties in Germany were performed in patients over 65, it follows that sport is of somewhat lesser importance to many of these older patients [5]. In addition, the EPRD's 2021 annual report indicates that nearly half of TKA patients are obese, according to the BMI data, with the highest proportion of obese TKA patients being in the 45–65 age group [6].

However, the young patient cohort keeps expanding, and a proportion of these patients will always aspire to engage in high-impact sports. Today, a knee implant should not represent an absolute obstacle to athletic exertion. In general, provided that the patient has appropriate prior experience, engaging in sports appears to be a realistic goal. The authors of this article remain cautious in recommending sports activities involving repetitive peak loads, such as jogging, but do allow their patients to play tennis and golf and engage in activities such as skiing or cycling.

Limitations of this article:

1. The study design takes the form of a narrative review which also includes the empirical experiences of the senior author;
2. The impact of patient characteristics and differences in implant design cannot be fully addressed in this setting;
3. Most of the study results mentioned here relate to short-term or medium-term outcomes and do not allow a conclusive assessment of the risk to long-term arthroplasty survival associated with exercise.

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Conflict of Interest

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