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Effect of knee arthroplasty on sports participation and activity levels: a systematic review and meta-analysis

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ABSTRACT

Objective Desires and expectations of patients in regard to resume participation in sport activities after knee arthroplasty strongly increased in recent years. Therefore, this review systematically reviewed the available scientific literature on the effect of knee arthroplasty on sports participation and activity levels.

Design Systematic review and meta-analysis.

Data sources PubMed, Embase, SPORTDiscus and reference lists were searched in February 2019.

Studies eligibility criteria Inclusion of knee osteoarthritis patients who underwent total knee arthroplasty (TKA) and/or unicondylar knee arthroplasty. Studies had to include at least one preoperative and one postoperative measure (≥1 year post surgery) of an outcome variable of interest (ie, activity level: University of California, Los Angeles and/or Lower Extremity Activity Scale; sport participation: type of sport activity survey).

Results Nineteen studies were included, consisting data from 4074 patients. Knee arthroplasty has in general a positive effect on activity level and sport participation. Most patients who have stopped participating in sport activities in the year prior to surgery, however, do not seem to reinitiate their sport activities after surgery, in particular after a TKA. In contrast, patients who continue to participate in sport activities until surgery appear to become even more active in low-impact and medium-impact sports than before the onset of restricting symptoms.

Conclusions Knee arthroplasty is an effective treatment in resuming sports participation and physical activity levels. However, to achieve the full benefits from knee arthroplasty, strategies and guidelines aimed to keep patients capable and motivated to participate in (low-impact or medium-impact) sport activities until close before surgery are warranted.

What is already known?

- Knee arthroplasty is a well-accepted surgical procedure for end-stage knee osteoarthritis aiming to relieve pain, to restore normal knee function and to improve quality of life.
- Desires and expectations of patients in regard to resume participation in sport activities after knee arthroplasty strongly increased in recent years.

What are the new findings?

- Knee arthroplasty is an effective treatment in resuming sports participation and physical activity level, in particular in case patients remain active in low-impact to medium-impact sports until close prior to surgery.
- To achieve the full benefits from knee arthroplasty, strategies and guidelines aimed to keep patients capable and motivated to participate in (low-impact or medium-impact) sport activities until close before surgery are warranted.

INTRODUCTION

Knee arthroplasty (KA) is a well-accepted surgical procedure for end-stage knee osteoarthritis aiming to relieve pain, to restore normal knee function and to improve quality of life.[1 2] Both unicondylar knee arthroplasty (UKA) and total knee arthroplasty (TKA) procedures showcase good to excellent results based on clinical testing and patient-reported outcome measures.[2] In recent years, UKA procedures are gaining popularity in the management of unicompartmental knee osteoarthritis in comparison to TKA.[3 4] A UKA only replaces the compartment (medial or lateral) that demonstrates the most degenerative lesions and preserves both cruciate ligaments, which is believed to be beneficial for joint stability and proprioception.[5] UKA has been associated with less postoperative complications and a shorter hospital stay compared with TKA,[6–8] although UKA implants are more frequently revised.[9]

Last years, the number of KA procedures in western countries strongly increased, in particularly for relatively younger and more active individuals.[10 11] This trend leads to increased desires and expectations of patients in regard to continued participation in sports activities after KA.[12 13] There is wide consensus that regular exercise is essential for healthy ageing and offers many health benefits, including beneficial effects on the cardiovascular system, muscle strength,

coordination, balance and general well-being,[14–16] and reduced risk of all-cause mortality.[17] In this respect, it is known that there are complex factors that affect participation in physical activity after KA such as knee function, personal barriers and beliefs, self-efficacy, social support and ageing.[18] Recommendations regarding participation in a particular sport after KA are currently however still mainly based on expert opinions rather than on scientific foundation.[12 13 15 19–24]

There has been considerable debate about the potentially negative long-term effects of participation in sport activities on prosthetic wear, loosening and revision rates,[13–16 19–21] despite evidence for this being rather limited.[25 26] The potential negative complications of returning to sports should be considered in balance to the beneficial effects of exercise as stated above.[14–16] Patients who participated in sport following KA were found, for example, to have significantly better postoperative knee scores and lower body mass index when compared with inactive patients, although there is large variation.[27–32] Pietschmann *et al*[27] even found that active patients tended to have less pain after surgery, although others have not reported such a relation between reported pain relief and number of sport activities.[33–35] Importantly though, patients who become involved in sports activities after knee surgery are in general more satisfied with the outcome of the surgery,[27 28 33 36 37] among the perceived facilitators and barriers to exercise after surgery, reasons not related to the replaced knee are reported more frequently than those related to the replaced knee.[27 33 37] As such, an increasing number of experts propagates nowadays for increasing activity after KA, excluding high impact and/or contact sports.

The incline in surgical procedures, the increased desires and expectations of patients to continue participation in sports activities, and the well-established positive impact of exercise on experienced quality of life, urge the need for evidence-based guidelines on sport participation after KA. As a first step to improve our insights on this topic, the present review aimed to systematically evaluate the available scientific literature on the effect of KA procedures on sports participation and activity levels after the rehabilitation period. Three research questions have been formulated in order to fully elucidate the aim of this review: (1) how does sports participation and activity level change from 1 year prior to knee replacement surgery (Pre-KA) to at least more than 1 year post-knee arthroplasty (Post-KA)? (2) How does sports participation and activity level change from before the onset of restricting symptoms (Pre-ORS) to within 1 year pre-surgery (Pre-KA)? (3) How does sports participation and activity level change from Pre-ORS to at least more than 1 year Post-KA? For each research question, we will look into the effect of KA in general, as well as evaluate the effect of UKA and TKA procedures in specific, on sports participation and activity levels. We hypothesise KA will have a positive effect on sports participation and activity levels compared with the situation from within 1-year presurgery, in particular in patients who remain active until close before surgery. In comparison to Pre-ORS, we expect participation in low-impact sports to increase after KA, while we expect participation in high-impact sports to decrease. In addition, we expect sport participation to be higher after UKA in comparison to TKA.

METHODS

This review was conducted according to the Preferred Reporting Items for Systematic Reviews andMeta-Analyses guidelines.[38]

Search strategy

The electronic databases of PubMed, Embase and SPORTDiscus were searched for relevant literature published after 1 January 2000. Searches were performed until 15 February 2019. In all three databases, the following two categories of keywords (and related synonyms) were used to build a sensitive, systemic search strategy: (1) 'knee arthroplasty', (2) 'sports' and/or 'activity'. In PubMed, we strived to use medical subject headings; otherwise, we searched the title, or title and/or abstract. Furthermore, search terms were truncated through the use of a * symbol in order to find all terms beginning with a specific word. The exact details of the search strategy can be found in online supplementary appendix A. Results were filtered for retrieval of only studies which used human participants.

Inclusion criteria and study selection

After removal of duplicates, the first author (MJK) screened all entries by both title and abstract. Hereafter, the first author (MJK) scanned the full-text of all eligible studies against the inclusion and exclusion criteria. In addition, the reference lists of selected articles were screened to identify additional articles to be included. Inclusion criteria were (1) patients with knee osteoarthritis who underwent TKA and/or UKA; who (2) intended to initiate or resume any level of sport activity after surgery; and (3) studies that included at least one preoperative and one postoperative measure (≥1 year post surgery) of an outcome variable of interest. The outcome variable of interest to assess sport activity levels was University of California, Los Angeles (UCLA) rating scores. Studies using Lower Extremity Activity Scale (LEAS) scores were included as well, as LEAS scores can be converted into UCLA scores as described in Ghomrawi *et al*.[39] Type of sport activity surveys, describing the number of participants active in a certain sport activity at a particular point in time, were used as the outcome variable of interest to assess sports participation. To ensure postoperative sports participation and activity levels are not confounded by knee functional scores, at least one postoperative measure needed to occur 1 year or longer after the date of surgery. This is because evidence suggests that the greater part of the knee function will have been regained at 1 year after surgery.[40–42] Furthermore, (4) only original investigation studies (ie, no conference

abstracts, review papers, editorials, etc), and (5) studies written in English were included.

Methodological quality

The first author (MJK) assessed the methodological quality of the included studies using the Methodological Index for Non-Randomized Studies (MINORS[43]). This quality assessment method contains eight items being for both comparative and non-comparative studies, and four additional items in the case of comparative studies. MINORS has been shown to be a valid and reliable instrument designed to assess the methodological quality of non-randomised surgical studies.

Data extraction

The first author (MJK) extracted data from all selected original articles. A standardised data extraction form was used including the following topics: (1) study information: authors, year and reference number; (2) study design and type of data collection; (3) patient characteristics: sex, age, type of surgery, follow-up period; (4) preoperative and postoperative sports participation data (yes/no); (5) preoperative and postoperative activity level data (UCLA or LEAS; yes/no); (6) study biases; (7) follow-up losses/non-responders.

Pooling data

From the studies that described preoperative and postoperative participation in specific types of sport activities, data were pooled and categorised into low-impact, intermediate-impact or high-impact sport activities, according to the levels of impact on the knee joint[13 19 20] (see tables 1–3). Sports participation data were evaluated in respect to the number of sports per participant, and to number of sports per active participant, in which active participant is defined as any individual who was active in one or more sport activities at that particular point in time. This additional analysis of number of sports per active participant has been done to gain further insight into whether possible effects in sport activity participation are due to active patients changing their number of involved sports, inactive patients starting to participate in any sport activities, or active patients quitting completely with participation in any sport activities.

From the studies that described preoperative and postoperative sport activity levels using the UCLA and/or LEAS scales, data were pooled and a meta-analysis has been performed to determine the effect of knee replacement surgery on activity level more than 1 year after surgery expressed as change in UCLA score.

RESULTS

Study selection

The initial search identified 867 studies. A flow chart of the study selection process can be found in online supplementary appendix B. Ultimately, 19 studies were selected for the systematic review, consisting of data from in total 4074 patients.[27–31 33 34 36 37 44–53] Twelve studies reported data preoperatively and postoperatively on activity levels (2899 patients[29 33 34 36 37 44–46 48 49 51 52]), while 15 studies reported data on sport participation (2007 patients[27–31 33 37 46–53]). Detailed information about each included study can be found in table 4.

Methodological quality

The methodological quality of the included studies, scored by using MINORS,[43] can be found in table 5. The average MINORS score of the included studies was 11.9±1.5 (range: 9–15) out of a maximum possible score of 16. Notable common points of concern were a lack of an a priori power analysis (n=16 studies without power analysis; n=2 studies with post-hoc power analysis), potential recall bias due to retrospective collection of data (n=11 studies), follow-up loss of more than 5% of participants or unspecified follow-up loss (n=12 studies) and a potential selection bias due to the participants exclusion criteria (n=3 studies).

Participation in sport activities

Pre-KA versus Post-KA

Eight studies examined the number of sport activities of in total 873 participants from Pre-KA to Post-KA.[30 33 47 48 50–53] An overview of the participation in sport activities by the participants Pre-KA and Post-KA can be found in table 1. The change in mean number of sport activities of active participants from Pre-KA to Post-KA showed a quite similar pattern as the change in mean number of sport activities for all participants (see table 1).

Pre-TKA versus Post-TKA

Out of the eight studies, five focused on only patients who had a TKA (741 patients[13 37 43 45 47]), while Ho *et al*[52] had a mixed group. Pre-TKA 49.1% did not participate (anymore) in any kind of sport activity. Post-TKA 48.7% did not participate in any kind of sport activity. The mean number of sport activities per participant increased from Pre-TKA to Post-TKA (mean 1.9 vs 2.4 sport activities). This increase in number of sport activities Post-TKA was found in low-impact (mean 1.2 vs 1.4 sport activities), medium-impact (mean 0.4 vs 0.6) and high-impact sports (mean 0.3 vs 0.4). Similar outcomes were found when looking at the mean number of sport activities per active participant (total: 3.7 vs 4.7 sport activities; low impact: 2.3 vs 2.8; medium impact: 0.8 vs 1.1; high impact: 0.6 vs 0.8).

Pre-UKA versus Post-UKA

Two studies focused on only patients with UKA (160 patients,[19 46]) while Ho *et al*[36] had a mixed group of patients with UKA and TKA. Pre-UKA, 21.9% of patients did not participate (anymore) in any kind of sport activity. Post-UKA, 13.8% did not participate in any kind of sport activity. The mean number of total sport activities remained quite stable from Pre-UKA to Post-UKA (mean 2.9 vs 2.8 sport activities). A very small increase in number of sport activities Post-UKA was found in low-impact (mean 1.3 vs 1.4), and medium-impact sports (mean

Table 1 Participation per sport activity within 1 year prior (Pre-KA) and more than 1 year after knee arthroplasty (Post-KA; n=873)

	Pre-KA	Post-KA	±	Unit of measure
Total sport activities	2.1	2.7		Mean N activities per participant
	4.3	5.0		
Low-impact sport activities	1.3	1.6		Mean N activities per participant
	2.5	2.9		Mean N activities per active participant
Swimming	371	449	+178	N participants
Cycling	368	484	+116	N participants
Walking	271	325	+54	N participants
Golf	45	46	+1	N participants
Aqua aerobic	20	33	+13	N participants
Fishing	18	12	−6	N participants
Gate ball	3	4	+1	N participants
Croquet	2	1	−1	N participants
Medium-impact sport activities	0.5	0.7		Mean N activities per participant
	1.0	1.3		Mean N activities per active participant
Hiking/Nordic walking	309	476	+167	N participants
Fitness/aerobics	51	64	+13	N participants
Bowling	24	20	−4	N participants
Cross-country skiing	23	27	+4	N participants
Badminton	10	7	−3	N participants
Table tennis	5	3	−2	N participants
Rowing	3	0	−3	N participants
High-impact sport activities	0.4	0.5		Mean N activities per participant
	0.8	0.8		Mean N activities per active participant
Skiing/snowboarding	131	150	+19	N participants
Dancing	91	117	+26	N participants
Running/jogging	53	46	−7	N participants
Gymnastics	32	37	+5	N participants
Tennis/squash	29	31	+2	N participants
Ball sports*	12	4	-8	N participants
Mountain climbing	2	7	+5	N participants
Other†	34	53	+19	N participants
No participation in any sport activity	50%	46%		% of total participants
Participation in ≥1 sport activities	50%	54%		% of total participants

*Ball sports include: soccer, basketball, volleyball and handball.
†Other involves undefined sport activities.

0.8 vs 0.9). However, the mean number of high-impact sport activities did strongly decline Post-UKA (mean 0.8 vs 0.5). The mean number of sport activities per active participant did decline from Pre-UKA to Post-UKA for the total number of sport activities (mean 3.7 vs 3.2) and the number of high-impact sport activities (mean 1.0 vs 0.6), but the change in mean number of low-impact sport activities (1.1 vs 1.1) and medium-impact sport activities remained rather similar (1.6 vs 1.6).

Pre-ORS versus Pre-KA

Three studies (in total 453 participants) examined the number of sport activities from Pre-ORS up to within 1 year Pre-KA.[30 52 53] An overview of the participation in sport activities by the participants Pre-ORS and Pre-KA can be found in table 2. The change in mean number of sport activities per active participant from Pre-ORS to Pre-KA showed a quite similar pattern as the change in mean number of sport activities for all participants, except the relatively much smaller decline from Pre-ORS to Pre-KA in low-impact sport activities (see table 2).

Pre-ORS versus Pre-TKA

Two studies focused on only patients who had a TKA (381 patients[37 47]), while Ho *et al*[36] had a mixed group. When looking only at patients with TKA, 5% did not participate

Table 2 Participation per sport activity before onset of restricting symptoms (Pre-ORS) and within 1 year to surgery (Pre-KA; n=453)

	Pre-ORS	Pre-KA	±	Unit of measure
Total sport activities	2.7	0.8		Mean N activities per participant
	2.9	1.8		Mean N activities per active participant
Low-impact sport activities	1.2	0.5		N activities per participant
	1.3	1.1		Mean N activities per active participant
Cycling	268	111	−157	N participants
Swimming	211	115	−96	N participants
Golf	35	10	−25	N participants
Aqua aerobic	16	12	−4	N participants
Medium-impact sport activities	0.7	0.1		Mean N activities per participant
	0.8	0.3		Mean N activities per active participant
Hiking/Nordic walking	234	36	−198	N participants
Fitness/aerobics	48	13	−35	N participants
Cross-country skiing	30	15	−15	N participants
Bowling	10	2	−8	N participants
High-impact sport activities	0.8	0.2		Mean N activities per participant
	0.9	0.3		Mean N activities per active participant
Skiing/snowboarding	121	17	−104	N participants
Gymnastics	74	24	−50	N participants
Dancing	69	18	−51	N participants
Running/jogging	55	4	−51	N participants
Ball sports*	43	5	−38	N participants
Tennis/squash	14	2	−12	N participants
Mountain climbing	3	1	−2	N participants
No participation in any sport activity	7%	51%		% of total participants
Participation in ≥1 sport activities	93%	49%		% of total participants

*Ball sports include: soccer, basketball, volleyball and handball.

Pre-ORS in one or more sport activities. Pre-TKA, 52% did not participate in any kind of sport activity. The mean number of sport activities per patient with TKA strongly declines from Pre-ORS to Pre-TKA (mean 2.9 vs 0.9 sport activities). This decline in number of sport activities Pre-TKA can be seen in low-impact (mean 1.2 vs 0.6 sport activities), medium-impact (mean 0.8 vs 0.2) and high-impact sports (mean 0.9 vs 0.2). Even when adjusting sport activities to only active participants, a decline has been found in all types of sport from Pre-ORS to Pre-TKA (total: 3.0 vs 1.9 sport activities; low impact: 1.3 vs 1.2; medium impact: 0.8 vs 0.3; high impact: 1.0 vs 0.3).

Pre-ORS versus Pre-UKA

No study looked into the change in number of sport activities from Pre-ORS to Pre-UKA for patients with UKA exclusively.

Pre-ORS versus Post-KA

Ten studies examined the number of sport activities of in total 1134 participants from Pre-ORS up to at least more than a year Post-KA.[27–31 37 46 49 52 53] An overview of the participation in sport activities by the participants Pre-ORS and Post-KA can be found in table 3.

The participation in number of sport activities of active participants showed a rather different pattern as the total group of participants. The mean number of sport activities showed only a relatively small decline Post-KA versus Pre-ORS in active participants (3.0 vs 2.8 sport activities), while an increase in the mean number of low-impact (1.2 vs 1.4) and medium-impact sport activities (0.8 vs 0.9) per active participant has been found from Pre-ORS to Post-KA. Only the mean number of high-impact activities per active participant showed a strong decline Post-KA in comparison to Pre-ORS (1.0 vs 0.5).

Table 3 Participation per sport activity before onset of restricting symptoms (Pre-ORS) and after knee arthroplasty (Post-KA; n=1134)

	Pre-ORS	Post-KA	±	Unit of measure
Total sport activities	2.6	1.8		Mean N activities per participant
	3.0	2.8		Mean N activities per active participant
Low-impact sport activities	1.0	0.9		N activities per participant
	1.2	1.4		Mean N activities per active participant
Cycling	588	463	−125	N participants
Swimming	382	347	−35	N participants
Walking	114	115	+1	N participants
Golf	61	56	−5	N participants
Aqua aerobic	33	53	+20	N participants
Bowls	3	3	0	N participants
Fishing	2	2	0	N participants
Shooting	1	1	0	N participants
Medium-impact sport activities	0.7	0.6		Mean N activities per participant
	0.8	0.9		Mean N activities per active participant
Hiking/Nordic walking	577	454	−123	N participants
Fitness/aerobics	105	132	+27	N participants
Cross-country skiing	98	37	−61	N participants
Bowling	19	11	−8	N participants
Badminton	18	8	−10	N participants
Horse riding	3	0	−3	N participants
Table tennis	1	1	0	N participants
High-impact sport activities	0.9	0.3		Mean N activities per participant
	1.0	0.5		Mean N activities per active participant
Skiing/snowboarding	246	54	−192	N participants
Gymnastics	157	96	−61	N participants
Dancing	143	93	−50	N participants
Running/jogging	131	23	−108	N participants
Ball sports*	123	24	−99	N participants
Tennis/squash	120	34	−86	N participants
Mountain climbing	33	11	−22	N participants
Skating	19	4	−15	N participants
Ice hockey	2	1	−1	N participants
Boxing	1	0	−1	N participants
Other†	17	14	−3	N participants
No participation in any sport activity	11%	35%		% of total participants
Participation in ≥1 sport activities	89%	65%		% of total participants

*Ball sports include: soccer, basketball, volleyball and handball.
†Other involves undefined sport activities.

Pre-ORS versus Post-TKA

Out of the 10 studies, 3 focused on only TKA (617 patients,[37 47 49]) while Ho *et al*[36] had a mixed group. When looking only at patients who got a TKA, 3% did not participate in any kind of sport activity Pre-ORS. Post-TKA 44% did not participate in any kind of sport activity. The mean number of sport activities per patient declined from Pre-ORS to Post-TKA (mean 2.9 vs 1.7 sport activities). This decline in number of sport activities Post-TKA could be seen in low-impact (mean 1.0 vs 0.8 sport activities), medium-impact (mean 0.8 vs 0.6) and high-impact sports (mean 1.0 vs 0.4). Remarkably, when looking at the number of sport activities per active participant, the total number of sport activities remained rather similar Post-TKA in comparison to Pre-ORS (total: 3.0 vs 3.0 sport activities). The mean number of low-impact (mean 1.1 vs 1.4) and medium-impact sport activities (mean 0.9 vs 1.0) even increased Post-TKA, while only the mean number of high-impact sport activities declined (mean 1.0 vs 0.6).

Table 4 Detailed overview of included studies on study design, study population, measure of sports participation, measure of activity level, study biases and follow-up loss

Study	Design	Study population	Sport participation	Activity level (UCLA/LEAS)	Study biases	Follow-up loss/non-responders
Chang *et al*[33]	Retrospective study	▶ 339 female, 30 male patients. ▶ Mean age: 68.8 years (range 50–83 years) ▶ TKA ▶ Follow-up: mean 2 years (range 1–3)	Yes	Yes (UCLA)	▶ Potential recall bias ▶ No power calculation	Non-responders: 198 out of 567 (35%)
Scott *et al*[44]	Retrospective study Prospective data collection	▶ 14 female patients, 16 male patients ▶ Mean age: 58±5 years (range 46–64) ▶ Non-consecutive revision TKA ▶ Follow-up: mean 3.8±2.2 years (range 1–9)	No	Yes (UCLA)	▶ No power calculation	No follow-up loss (0%)
Scott *et al*[45]	Retrospective study Prospective data collection	▶ 148 female patients, 141 male patients ▶ Mean age 59 years (range 42–65) ▶ TKA ▶ Follow-up: mean 3.4 years (range 2–5)	No	Yes (UCLA)	▶ No power calculation	No follow-up loss (0%)
Ponzio *et al*[36]	Retrospective study Prospective data collection	▶ 1140 female patients, 876 male patients ▶ Mean age: 66.3±9.0 years ▶ Unilateral primary TKA ▶ Follow-up: 2 years after surgery	No	Yes (LEAS)	▶ Potential selection bias: participants with low preoperative LEAS scores excluded; ▶ No power calculation	Follow-up loss: 517 out of 2016 (26%)
Panzram *et al*[46]	Retrospective study	▶ 12 female patients, 15 male patients ▶ Mean age: 62.5 years (range 49–76) ▶ Cementless medial UKA ▶ Mean follow-up: 60±8 months (range 47–69)	Yes	Yes (UCLA)	▶ Potential recall bias ▶ No power calculation	Follow-up loss: 3 out of 27 (11%)
Chatterji *et al*[47]	Retrospective study	▶ 80 female patients, 64 male patients ▶ Mean age: 70.8±10.4 years ▶ TKA ▶ Follow-up: between 1 and 2 years after surgery	Yes	No	▶ Potential recall bias ▶ No power calculation	Follow-up loss: 34 out of 178 (19%)

Continued

Table 4 Continued

Study	Design	Study population	Sport participation	Activity level (UCLA/LEAS)	Study biases	Follow-up loss/non-responders
Canetti *et al*[48]	Retrospective study	▶ 21 female patients, 7 male patients ▶ Mean age: 64.6±9.0 (range 35–79) ▶ Lateral UKA ▶ Mean follow-up: 37±5 months (range 15–68)	Yes	Yes (UCLA)	▶ Potential recall bias ▶ Potential selection bias: no preoperative sports participation as exclusion criteria; ▶ No power calculation	No follow-up loss (0%)
Williams *et al*[34]	Retrospective study Prospective data collection	▶ 155 female, 94 male patients ▶ Mean age: 67.5±9.9 years (range 45–93) ▶ 232 TKA, 17 UKA ▶ Mean follow-up: 12.1 months; range 11–13.	No	Yes (UCLA)	▶ No power calculation	Not reported for patients with knee arthroplasty
Naal *et al*[28]	Retrospective study	▶ 38 female, 45 male patients ▶ Mean age: 65.5±9.1 (range 47–83) ▶ UKA ▶ Mean follow-up: 18±5 months (range 12–28)	Yes	No	▶ Potential recall bias ▶ No power calculation	Follow-up loss: 19 out of 102 (19%)
Walker *et al*[37]	Retrospective study	▶ 26 female, 19 male patients ▶ Mean age: 60.1±10.5 years (range 36–81) ▶ Lateral UKA ▶ Mean follow-up: 35±8 months (range 24–51)	Yes	Yes (UCLA)	▶ Potential recall bias ▶ No power calculation	Follow-up loss: 1 out of 46 (2%)
Fisher *et al*[29]	Prospective study	▶ 34 female patients, 32 male patients ▶ Mean age: 64 years (range 49–81) ▶ Oxford medial UKA ▶ Mean follow-up: 18 months (range 4–46)	Yes	Yes (UCLA)	▶ No power calculation	Follow-up loss: 9 out of 75 (12%)
Huch *et al*[53]	Prospective study	▶ 216 female patients, 84 male patients ▶ Mean age: 66.0±6.4 years ▶ TKA ▶ Follow-up: 5 years after surgery	Yes	No	▶ No power calculation	Follow-up loss: 89 out of 389 (23%)

Continued

Table 4 Continued

Study	Design	Study population	Sport participation	Activity level (UCLA/LEAS)	Study biases	Follow-up loss/non-responders
Pietschmann *et al*[27]	Retrospective study	▶ 74 female patients, 57 male patients ▶ Mean age: 65.3 years (range 44–90 years) ▶ Medial UKA Oxford III ▶ Mean follow-up: 4.2 years (range 1–10)	Yes	No	▶ Unclear if data collection preoperatively and postoperatively was done at same time or not; ▶ No power calculation	Follow-up loss: 38 out of 169 (22%)
Jahnke *et al*[51]	Prospective study	▶ 63 female patients, 72 male patients ▶ Mean age: 63.5 years (range 36–86) ▶ Medial Oxford UKA ▶ Follow-up: 5 years later	Yes	Yes (UCLA)	▶ No power calculation	Follow-up loss: 24 out of 159 (15%)
Vielgut *et al*[31]	Retrospective study	▶ 193 female patients, 43 male patients ▶ Mean age: 62.7±11.4 years ▶ TKA ▶ Follow-up: minimum of 10 years post surgery	Yes	No	▶ Potential recall bias ▶ Potential selection bias: participant screening preoperative sports participation; ▶ Post-hoc power calculation	Follow-up loss: 8 out of 244 (3%)
Mayr *et al*[30]	Retrospective study	▶ 43 female, 38 male patients from alpine area ▶ Mean age of 71.8±5.4 years ▶ TKA ▶ Mean follow-up: 6.4±0.9 years	Yes	No	▶ Potential recall bias	Follow-up loss: 2 out of 83 (2%)
Hepperger *et al*[50]	Prospective study	▶ 120 female, 80 male patients from alpine area ▶ Mean age: 72.2±7.7 years ▶ Primary TKA ▶ Follow-up: 24 months post surgery	Yes	No	▶ Post-hoc power calculation	Follow-up loss: 3 out of 203 (1%)
Walker *et al*[49]	Retrospective study	▶ 47 female patients, 46 male patients ▶ Mean age: 55±5 years (range 36–60) ▶ Medial UKA ▶ Mean follow-up: 4.4±1.6 years (range 2–8)	Yes	Yes (UCLA)	▶ Potential recall bias ▶ No power calculation	Follow-up loss: 8 out of 101 (8%)

Continued

Table 4 Continued

Study	Design	Study population	Sport participation	Activity level (UCLA/LEAS)	Study biases	Follow-up loss/non-responders
Ho *et al*[52]	Retrospective study	► 48 female patients, 24 male patients ► Mean age 60.0 years (range 53–64) ► 33 UKA, 39 TKA ► Mean follow-up: 45.6 months (range 24–68)	Yes	Yes (UCLA)	► Potential recall bias ► No power calculation	Follow-up loss not specified

LEAS, Lower Extremity Activity Scale; TKA, total knee arthroplasty; UCLA, University of California, Los Angeles; UKA, unicondylar knee arthroplasty.

Pre-ORS versus Post-UKA

Six studies focused on only patients who had a UKA (445 patients[33 34 39 41 44 48]), while Ho *et al*[36] had a mixed group. Of the patients who got a UKA, 22% did not participate (anymore) in any kind of sport activity Pre-ORS. Post-UKA, 25% did not participate in any kind of sport activity. The mean number of total sport activities per participant did decline from Pre-ORS to Post-UKA (mean 2.4 vs 2.0 sport activities), mainly due to a reduced number of high-impact sports Post-UKA (mean 0.7 vs 0.2). The mean number of sport activities per participant in low-impact (mean 1.1 vs 1.1) and medium-impact sports (mean 0.6 vs 0.6) was rather similar at Pre-ORS and Post-UKA. Comparable outcomes were found when looking at the number of sport activities per active participant (total: 3.1 vs 2.6 sport activities; low impact: 1.4 vs 1.5; medium impact: 0.8 vs 0.8; high impact: 0.9 vs 0.3)

Activity level

Pre-KA versus Post-KA

Nine studies reported UCLA scores within 1 year prior to surgery and more than 1 year postoperatively,[29 33 34 37 44–46 48 49]

Table 5 The methodological quality of the included studies scored using Methodological Index for Non-Randomized Studies

Study	1. A clearly stated aim	2. Inclusion of consecutive patients	3. Prospective collection of data	4. Endpoint appropriate to the study aim	5. Unbiased assessment of endpoints	6. Follow-up period appropriate to study aim	7. Loss to follow-up not exceeding 5%	8. Prospective calculation of the study size	Total score*
Chang *et al* [33]	2	1	1	2	2	2	1	0	11/16
Scott *et al* [44]	2	1	2	1	2	2	2	0	12/16
Scott *et al* [45]	2	2	2	1	2	2	2	0	13/16
Ponzio *et al* [36]	2	2	2	2	1	2	1	0	12/16
Panzram *et al* [46]	2	2	1	2	2	2	1	0	12/16
Chatterji *et al* [47]	2	2	1	2	2	2	1	0	12/16
Canetti *et al* [48]	2	1	1	2	1	2	2	0	11/16
Williams *et al* [34]	2	2	2	1	2	1	0	0	10/16
Naal *et al* [28]	2	2	1	2	2	2	1	0	12/16
Walker *et al* [37]	2	2	1	2	2	2	2	0	13/16
Fisher *et al* [29]	2	2	2	2	2	1	1	0	12/16
Huch *et al* [53]	2	2	2	2	2	2	1	0	13/16
Pietschmann *et al* [27]	2	2	0	1	2	2	1	0	10/16
Jahnke *et al* [51]	2	0	2	2	2	2	1	0	11/16
Vielgut *et al* [31]	2	1	1	2	1	2	2	1	12/16
Mayr *et al* [30]	2	2	1	2	2	2	2	2	15/16
Hepperger *et al* [50]	2	2	2	2	2	2	2	1	15/16
Walker *et al* [49]	2	2	1	2	2	2	1	0	12/16
Ho *et al* [52]	2	0	1	2	2	2	0	0	9/16

*The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). The global ideal score being 16 for non-comparative studies.

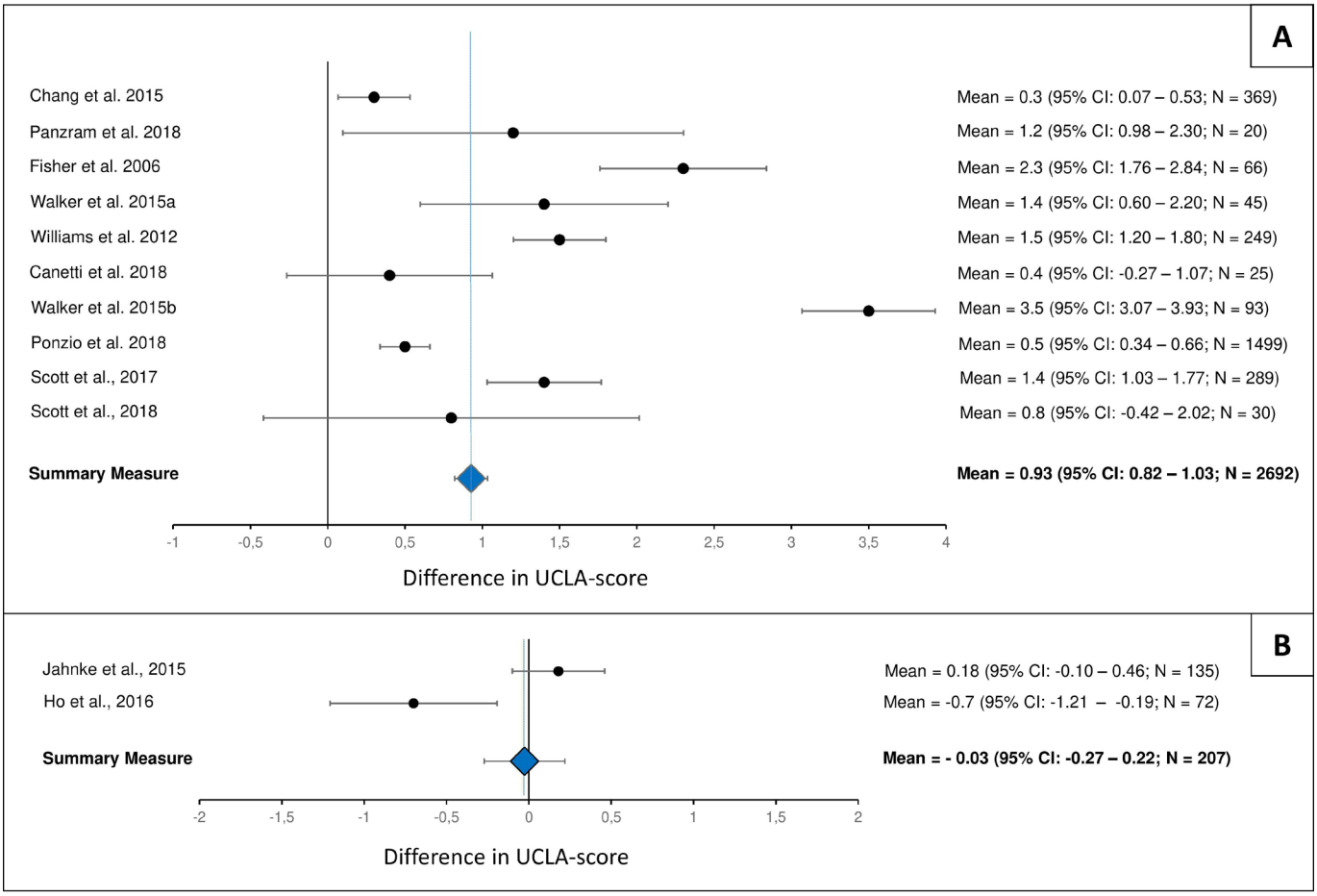

Figure 1 Meta-analysis on change in UCLA (University of California, Los Angeles) scores from within 1-year pre-knee replacement surgery to more than 1-year post-knee replacement surgery (n = 10 studies; N = 2692 participants; upper section A); and meta-analysis onchange in UCLA scores from pre-onset of restricting symptoms to more than 1-year post-knee replacement surgery (n = 2 studies; N = 207 participants; lower section B).

while one study reported LEAS scores.[36] The effects of KA on activity level (ie, UCLA score) relative to within 1 year pre-knee replacement surgery can be found in figure 1. The summary measure of the meta-analysis of 2692 participants revealed that the mean UCLA score more than a year Post-KA improved in comparison to the UCLA score within 1 year prior to surgery (Pre-KA: 5.6±1.1; Post-KA: 6.5±1.2).

Half of the 10 studies focused on patients who had an UKA,[13 20 38 40 42] while the other half focused primarily on patients with TKA.[19 33 34 39 41] An additional analysis revealed that the extent of the improvement in UCLA scores was higher after UKA (mean improvement in UCLA score: 2.3±0.4; 256 patients), in comparison to TKA (mean improvement: 0.7±0.2; 2436 patients). The Post-KA UCLA scores were almost similar regardless of type of surgery (UKA Post-KA: 6.6±1.4; TKA Post-KA: 6.5±2.0).

Pre-ORS versus Pre-KA

No studies have been found that measured the change in activity level from Pre-ORS to within the year before surgery.

Pre-ORS versus Post-KA

Two studies reported UCLA scores Pre-ORS and more than 1 year postoperatively.[51 52] The effects of KA on activity level (ie, UCLA score) relative to Pre-ORS can be found in figure 1. The summary measure of the meta-analysis of 207 participants revealed that the mean UCLA score did not differ between Pre-ORS and Pre-KA (mean=−0.03; 95% CI −0.27 to 0.22). No additional analyses were performed into possible differences between UKA and TKA due to the low number of studies.

DISCUSSION

This review aimed to systematically review the scientific literature on the effect of KA on sports participation and activity levels. KA has been found to have in general a positive effect on sports participation and activity level in comparison to the situation in the year before surgery, with activity levels returning in the years after KA to a similar level as Pre-ORS. Most patients who have stopped participating in sport activities in the year prior to surgery, however, do not seem to reinitiate their sport activities after surgery, in particular in case of TKA. In contrast, patients who continued to participate in sport activities

until surgery appear to become similarly or even more active in low-impact and medium-impact sports than Pre-ORS. Participation in high-impact sports strongly declined in comparison to Pre-ORS.

As one may expect, sport participation strongly declined from the period Pre-ORS until within 1 year prior to surgery. Prior to surgery, the majority of patients reported pain or a physical limitation due to their knee osteoarthritis (eg, loss of range of motion, stiffness, swelling, inability to stand for a long period of time, loss of strength, fatigue and fear of falling) as main barrier for participating in any sport activity.[46 54] The main cause reported for a change in sport activity was related to pain in the affected knee.[46] Following KA, sports participation and activity level improved in comparison to the year before surgery, with activity levels returning eventually to a similar level as Pre-ORS.[29 33 34 36 37 44–46 48 49 51 52] Patients who continued to participate in sport activities until close to surgery appear to become postoperatively even more active in low-impact and medium-impact sports than Pre-ORS, and as equal or even more active than a healthy age-matched population sample.[49 55 56] In this respect, given the apparent relationship between preoperative and postoperative participation in sport activities, the lack of clinical, evidence-based guidelines regarding sport activities prior to surgery is remarkable.

It is known that there are complex factors that affect participation in physical activity before and after knee surgery, such as knee function, personal barriers and beliefs, self-efficacy, social support and ageing.[18] Interestingly, among the perceived facilitators and barriers to exercise after surgery, reasons not related to the replaced knee are reported more frequently than those related to the replaced knee.[27 33 37] The most common facilitators to physical activity were related to the patients' motivation to improve symptoms or surgery outcomes, their personal commitment to physical activity and/or to engage in an active lifestyle, and conscious monitoring and awareness of activity levels to ensure they were being active throughout the day.[27 33 37 54] The most common reported barriers for participating in any sport activity after KA were a lack of motivation, precaution to preserve the prosthesis, a medical condition due to other comorbidities and pain or a physical limitation due to their knee.[27 33 37 53] Notably, it appears that men are more likely to return to sport postoperatively than women.[34 44 47 50 51 53 55 57] Among the measures of knee function, scores on the physical-related 36-Item Short Form Health Survey (SF-36) domains showed the strongest correlation with both number of sport activities[28] and activity level.[33] In this perspective, postoperative sport activities and activity levels appear to be more related to patient-specific factors rather than sociodemographic factors, type of surgery, implant, bearing surface diameter or operating surgeon.[34]

Based on the actual postoperative sport participation of patients as shown in this review and previous research,[18 58–61] the most popular sports were swimming, cycling and (Nordic) walking/hiking,[27–31 33 37 46–53] while participation in high-impact activities such as ball sports, running/jogging and skiing strongly decreased compared with Pre-ORS. After muscle strength and muscle control of the quadriceps and hamstring muscles have been sufficiently recovered,[13 19] it is encouraged to perform low-impact activities as they help improve general health and cardiovascular fitness. Muscular rehabilitation in terms of strength and coordination is in this sense important for the safety and protection of the joint, in which preoperative physiotherapy may be helpful to accelerate this recovery process postoperatively.[62–64] Although it is typically advised to strongly discourage patients with knee arthroplasty from participation in high-impact sports,[12 13 15 19–24] and a common sense of caution should be taken in mind, our findings do indicate that it is not impossible to participate in high-impact sport activities after KA. Notably, participation in (aqua)aerobics and fitness increased from Pre-ORS to Post-KA. During these medium-impact activities, it is recommended to put emphasis on a high number of repetitions with minimal resistance.[24]

In terms of sport participation and improvement in UCLA score postoperatively, our results indicate that a UKA procedure achieves better outcomes in comparison to TKA. Nevertheless, it can be questioned whether a fair comparison can actually be made between UKA and TKA procedures in relation to sport participation and activity level. A selection bias may possibly be present as (younger) patients who are more motivated and/or have higher expectations already prior to the surgical procedure in regard to continued participation in athletic activities after KA are more likely to receive a UKA procedure. Motivation and expectation level both have been proven indeed to positively affect sport participation and activity levels after KA.[35 36] As such, it can be argued that the reported differences in relation to sport and activity levels are a result of differences in motivation and expectation level of the involved patients groups already prior to the surgical procedure, rather than due to the used surgical procedure itself. This assumption is supported by our finding that patients with TKA who remained active until the period within 1 year prior to surgery showed a similar pattern as patients with UKA in terms of postsurgery sport participation.

A number of common methodological issues need to be taken into account for the interpretation of the presented outcomes of this systematic review. Due to the retrospective character of many studies, for example, sport participation questionnaires are prone to recall bias as many rely on a patient's ability to describe sporting activity several years before the study was carried out. Furthermore, many studies were faced with follow-up loss of more than 5%. It can be argued that the participants whom were lost in follow-up are likely to be less satisfied with their results of the surgical procedures in comparison to the reported data in this systematic review, leading to a possible underestimation of the negative outcomes.

Future studies are urged to take these potential biases into consideration when designing and performing their study. Finally, this review bears some limitations on itself that we would like to address, including the lack of an a priori registration of the review protocol and screening for inclusion by a single reviewer only. The authors acknowledge that screening for inclusion by a single reviewer lowers scientific rigour and enhances the potential risk of missing relevant literature. Despite the fact that the review protocol was set a priori by the authors and did not changed throughout the research process, a priori registration of the review protocol would have strengthened the study and is encouraged for future research.

CONCLUSIONS

KA is an effective treatment in relation to sports participation and activity level, with the potential to become as equal or even more active than healthy age-matched peers. Despite a decline in high-impact sports participation, our findings indicate that it is possible to return to similar levels of activity as Pre-ORS after both UKA and TKA. Patients who continued to participate in sport activities until close to surgery appear to become even more active in low-impact and medium-impact sports than Pre-ORS. Most patients who stopped participating in sport activities prior to surgery, however, do not seem to reinitiate their sport activities after surgery. As such, to achieve the full benefits out of KA, clinical guidelines and strategies aimed to keep patients capable and motivated to participate in sport activities until close before and after surgery are warranted.

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