Knee Surgery, Sports Traumatology, Arthroscopy (2021) 29:694–709
https://doi.org/10.1007/s00167-020-06400-y

KNEE

Twenty-one sports activities are recommended by the European Knee Associates (EKA) six months after total knee arthroplasty

Martin Thaler[1] · Ismail Khosravi[1] · David Putzer[2] · Michael T. Hirschmann[3] · Nanne Kort[4] · Reha N. Tandogan[5] · Michael Liebensteiner[1]

Received: 8 October 2020 / Accepted: 1 December 2020 / Published online: 6 January 2021

Abstract

Purpose To elaborate recommendations for sports participation following TKA among the members of the European Knee Associates (EKA).

Methods A prospective online survey was conducted among the members of the European Knee Associates (EKA). The European Knee Associates (EKA) are a section of the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA). The survey investigated recommendations for 47 sports disciplines. Possible answers were: allowed, allowed if experienced, not allowed, no opinion. The survey was conducted separately for 4 specific time frames: within 6 weeks after TKA; 6–12 weeks after TKA; 3–6 months after TKA; and more than 6 months after TKA. Consensus among the respondents was then analyzed.

Results EKA members ($N = 120$) participated in the survey. A high level of consensus was reached for a recommendation to allow 5 different sports in the first 6 weeks after TKA, 7 sports 6–12 weeks after surgery, 14 sports 3–6 months after TKA, and 21 out of 47 activities 6 months after surgery. In the first 6 weeks after TKA walking, stair climbing, swimming, aqua fitness, and static cycling were recommended. Six to twelve weeks after TKA, cycling on level ground and yoga were recommended in addition to the aforementioned activities. Further sports activities recommended beyond 12 weeks after TKA were: tennis doubles, golf, fitness/weight lifting, aerobics, hiking, Nordic walking and sailing. The sport for which the recommendation was "not allowed" following TKA was squash.

Conclusion The number of sports recommended by EKA surgeons increases stepwise over the postoperative time frames. The findings are regarded as clinically relevant as they may serve as a basis for answering patient questions on timing and giving recommendations for the resumption of sports activities following standard primary TKA and should be individualized by surgeons for their patients' expectations and goals.

Level of evidence V.

Keywords Knee replacement · Arthroplasty · Return to sports · Physical activity · Survey

Introduction

Total knee arthroplasty (TKA) is the gold standard in the surgical treatment of end-stage osteoarthritis [14]. In a more active and younger TKA population, early and successful rehabilitation is associated with the resumption of daily activities and a return to work and sports. The resumption of physical activities and sports is a paramount expectation for active patients.

In an aging, more active population, there is a steadily increasing functional demand following primary TKA. Sports activities also create opportunities for social interaction, being part of a community, developing

✉ Ismail Khosravi
ismail.khosravi@tirol-kliniken.at

1 Department for Orthopaedic Surgery and Traumatology, Medical University Innsbruck, Innsbruck, Austria

2 Department of Orthopaedic Surgery and Traumatology, Experimental Orthopaedics, Medical University of Innsbruck, Salurnerstrasse 35, 6020 Innsbruck, Austria

3 Department of Orthopaedic Surgery and Traumatology, Kantonsspital Baselland, (Bruderholz, Liestal, Laufen), University of Basel, 4101 Bruderholz, Switzerland

4 CortoClinics, Schijndel, The Netherlands

5 Ortoklinik and Cankaya Orthopaedics, Ankara, Turkey

relationships, attending competitions, achieving goals and contributing to the overall sense of successful aging [16]. Consequently, physical activity is a strong determinant of patients' quality of life and patients frequently ask if they will be able to continue sports after TKA surgery [3].

Although there is some evidence about return to sports after primary TKA [20], in daily clinical routine, surgeons refer to their personal experience, activity level and passion for sports when making recommendations to patients. Some recommendations on returning to sports are sometimes not evidence-based [5]. Most studies investigated only scattered sports activities [6], in that, they did not investigate a comprehensive set of variations of possible sports types. In addition, recommendations to return to sports activities are frequently biased by concerns held by arthroplasty surgeons about avoiding complications following TKA.

The aim of the study was to elaborate recommendations for returning to sports after TKA to be made by members of the European Knee Associates (EKA) a dedicated Europe-wide knee arthroplasty society. Moreover, for the first time, also different postoperative time frames were issued. Previous studies did not always reflect the whole range of sports practiced nowadays. The current study aimed to cover the majority of today's sports (47 types of sports). As previous studies addressed mainly North America, the current study's goal was to specifically address European surgeons' recommendations. This, because cultural differences exist between e.g., North America and Europe regarding the variety of sports is usually performed.

Materials and methods

A prospective online survey was performed among the members of the European Knee Associates (EKA). The European Knee Associates (EKA) are a section of the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA). Within ESSKA, the EKA is an association particularly dealing with the management of degenerative diseases of the knee joint. Consequently, its members focus on knee arthroplasty and osteotomy around the knee. The EKA currently has 208 members, all of whom were addressed by the survey.

A web-based survey (Survey Monkey, www.surveymonkey.com, Portland, OR, USA) was sent out via e-mail invitation. The survey listed 47 different activities (Fig. 1), and the surgeons were asked to assign their recommendations for resumption following primary TKA to one of the four categories: allowed, allowed if patient is experienced, not allowed, or no opinion. All questions for recommended sports participation were provided four-fold for the following time frames: for the first 6 weeks postoperatively, 6–12 weeks postoperatively, 3–6 months postoperatively, and beyond 6 months after surgery. Additional data were collected regarding healthcare facility status, specialization, surgical approach, preferred implant choice, preferred bearing surface, type of fixation and whether or not the surgeon usually resurfaces the patella. In addition, recommendations for different types and duration of physical therapy were recorded. The surgeons were also asked how frequently they performed sports and what their favorite sport was. Finally, the participants were asked to state what they feel is the greatest risk from physical activity following primary TKA.

Endurance sports	Water sports	Mountaineering	Winter sports	Ball sports	Contact sports	Fitness training	Miscellaneous
Walking	Swimming	Hiking	Skiing	Tennis doubles	Tai Chi	Fitness / Weight lifting	Horseback riding
Walking stairs	Aqua fitness	Nordic walking	Cross-country skiing / Nordic skiing	Tennis singles	Full contact sports (e.g. boxing)	Cross-training	Extreme sports
Jogging	Surfing	Climbing	Snowboarding	Golf	Martial arts	Yoga	Dancing
Jogging on road	Windsurfing	Canyoning	Ice skating / skating	Squash		Aerobics	Bowling
Running	Sailing		Sledging	Badminton			
Running on a treadmill	Rowing			Table tennis			
Mountainbiking / incline cycling	Canoeing			Handball			
Cycling on even ground	Kayaking			Volleyball			
Static cycling				Soccer / Football			
				Basketball			

Fig. 1 Categorized 47 physical activities investigated for safe performance following primary TKA

Statistical analysis

A power analysis for a "1-sample proportion test" determined that approximately 68% of each of the mentioned four categories would be required to achieve statistical significance (power = 0.95) based on the number of survey respondents ($N = 120$). All survey results were tabulated and the percentage was calculated.

For each activity surveyed, a "Z test" was performed to compare the percentage of responses given for each category (allowed, allowed if experienced, not allowed, and no opinion) and the percentage of responses required for significance (68%). A p value of 0.05 was considered statistically significant. The responses for allowed and allowed if experienced were grouped together and compared with the combined not allowed and no opinion groups. If the combined allowed and allowed if experienced group was significantly favored as compared with the combined not allowed and no opinion group, the overall recommendation was declared "recommended." If the combined not allowed and no opinion group was significantly favored as compared with the combined allowed and allowed if experienced group, the overall recommendation was classed as "not recommended." If no statistical significance was achieved for either comparison, the overall recommendation was declared "no opinion."

Results

One hundred and twenty EKA surgeons from 31 countries participated. The majority of the participants (60.2%) stated that they performed sports more than twice a week (Fig. 2). Regarding operating frequency, 67.2% performed over 50 total knee arthroplasties per year, with the largest group (31.9%) of surgeons stating that they performed between 51 and 100 total knee arthroplasties per year (see Fig. 3 for details). Regarding TKA design, almost half (46.2%) of the respondents favored posterior stabilized implants, whereas 37.0% preferred cruciate-retaining implants (Fig. 4). Aseptic loosening (33.3%) and polyethylene wear (29.9%) were considered the greatest risks involved in physical activity following primary TKA (Fig. 5). When asked for optimal duration of physical therapy following TKA, approximately one-third (35%) of the respondents recommended three mon ths.

In the first six weeks after TKA walking, stair climbing, swimming, aqua fitness, and static cycling were recommended. Six to twelve weeks after TKA cycling on level ground and yoga were recommended in addition to the aforementioned activities. Further sports activities were recommended beyond 12 weeks after TKA: tennis doubles, golf, fitness/weight lifting, aerobics, hiking, Nordic walking and sailing. More than six months postoperatively, the survey participants additionally recommended the following sports: mountain biking/ incline cycling, table tennis, rowing, canoeing, kayaking, skiing and Tai-Chi. Squash was not recommended even after more than six months postoperatively.

Sports types with consensus in part were as follows: Survey participants discouraged TKA patients from jogging, running, tennis singles, cross training, climbing, cross-country skiing/Nordic skiing in the first six postoperative weeks. However, for the following periods, there was no consensus. Jogging on a road, running on a

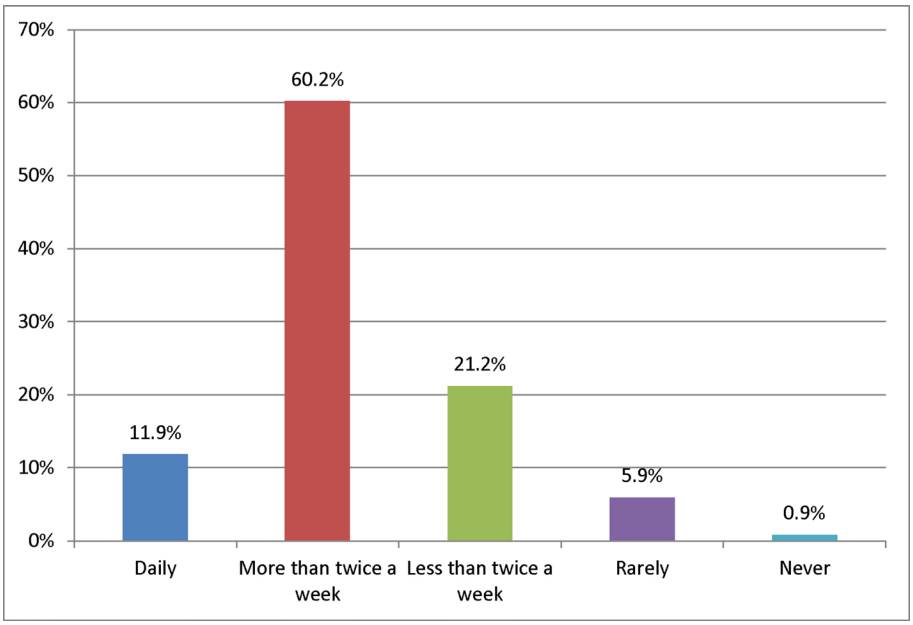

Fig. 2 Frequency of performance of sports activities by TKA surgeons per week

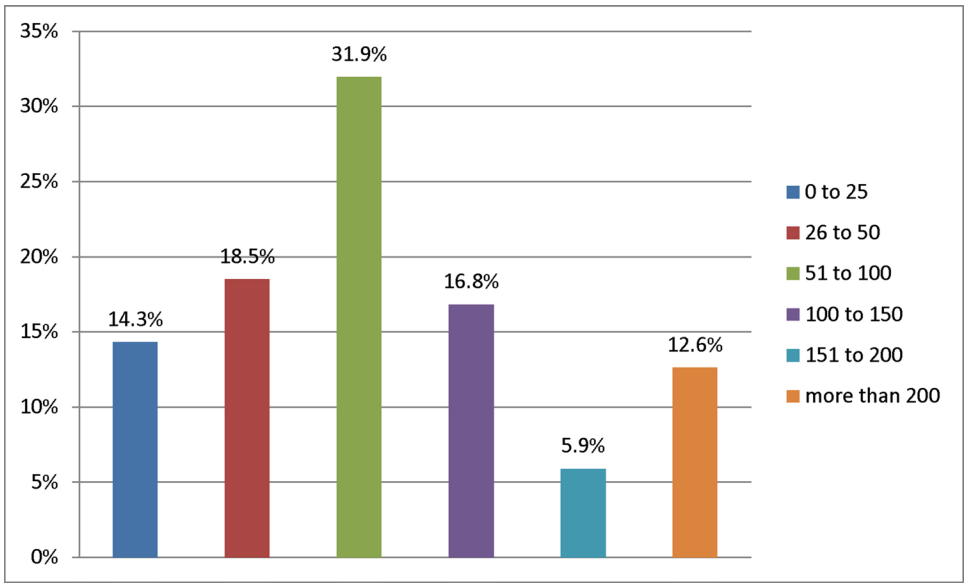

Fig. 3 Total knee arthroplasties performed per year per surgeon

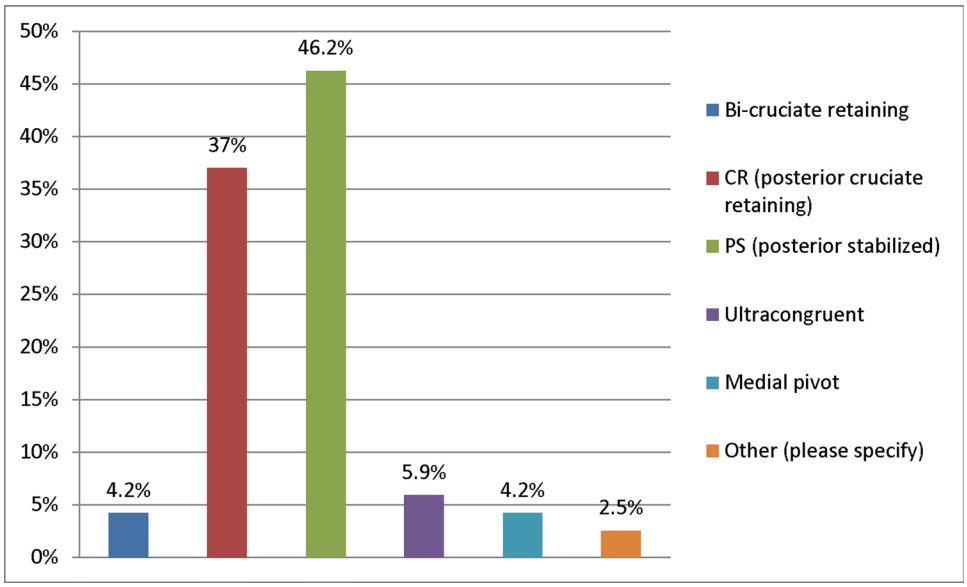

Fig. 4 Surgeons' preferred implant mechanisms

treadmill, handball, soccer, basketball, full contact sports, martial arts were not recommended until 12 weeks, but thereafter no consensus was seen among the survey participants. Badminton, volleyball, canyoning, surfing, windsurfing, snowboarding, tobogganing were not recommended until six months but no consensus thereafter.

Overall, after six months, 21 of 47 sports were recommended, for 20 sports no decision could be taken and one sport was defined as "not recommended." Further details are provided in Tables 1, 2, 3, 4, 5, 6, 7, 8 and visualized in Figs. 6, 7, 8, 9.

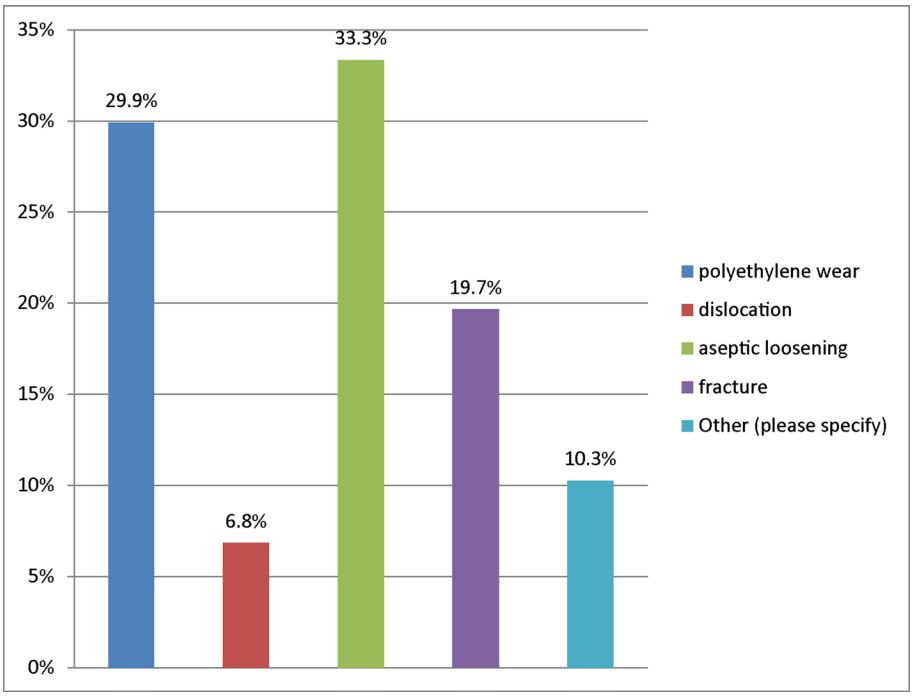

Fig. 5 Greatest risks from physical activity following primary TKA

Discussion

The most important finding of the study is the fact that the number of sports recommended following TKA increases stepwise over time. The EKA surgeons recommended five activities for the first 6 postoperative weeks, 7 activities for the period 6 to 12 weeks postoperatively, 14 activities for the period 3–6 months and 21 activities for the time beyond 6 months postoperatively. Other disciplines were either not recommended or failed to achieve a consensus among the EKA surgeons.

When attempting to compare the EKA recommendations for sports participation following TKA, we saw that literature pertaining to this subject is rare. This is because most research in the 'Sports & TKA context' focused on either (1) return to sports issues following TKA or (2) potentially increased the risk for osteoarthritis among physically active people. Only a minority of studies dealt with surgeons' recommendations for sports after TKA. Only McGrory et al. investigated surgeon preferences following TKA [10]. They surveyed 28 surgeons at their department about their recommendations for 28 different sports. Recommended sports after TKA were only golf, cycling, swimming, sailing, bowling, scuba diving and cross-country skiing. Remarkably, the set of sports covered in their study was considerably smaller than that in the current study, and the authors did not differentiate between postoperative time frames. Moreover, in vast contrast to the current study, the study by McGrory et al. analyzed the opinions of the surgeons at only one department [10]. Surgeons' recommendations for the period following TKA implantation were also published by Meester et al. [11], who asked 117 surgeons in the Netherlands to make a statement on 40 different sports. Approximately 50% of the given sports were regarded as recommended by the surgeons, which is in rough agreement with the current study. However, Meester et al. did not differentiate between several postoperative periods [11]. Also Straat et al. elaborated surgeons' recommendations for sports following TKA [17]. When applying the Delphi method among a panel of 6 surgeons, 5 physicians, 3 physical therapists and 1 physician assistant consensus was achieved regarding recommendations for 27 physical activities. For this purpose, authors differentiated between TKA patients recovering at an average rate, quickly, or slowly. From their findings, Straat et al. concluded that patients with fast recovery may resume cycling 6 weeks postoperatively, while those with average or slow recovery may return to cycling after 9 or 12 weeks, respectively [17]. Unfortunately, the remaining activities tested by

Table 1 Summary of recommendations for endurance sports

	Follow up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Walking	6 weeks	91.6	6.7	0.8	0.8	< 0.01	Recommended
	6–12 weeks	97.5	1.7	0.8	0.0	< 0.01	Recommended
	12 weeks to 6 months	94.1	1.7	4.2	0.0	< 0.01	Recommended
	6 months	91.6	1.7	6.7	0.0	< 0.01	Recommended
Climbing stairs	6 weeks	75.6	19.3	4.2	0.8	< 0.01	Recommended
	6–12 weeks	95.8	3.4	0.8	0.0	< 0.01	Recommended
	12 weeks to 6 months	92.4	1.7	5.9	0.0	< 0.01	Recommended
	6 months	94.1	1.7	4.2	0.0	< 0.01	Recommended
Jogging	6 weeks	3.4	13.4	76.5	6.7	< 0.01	Not recommended
	6–12 weeks	26.9	34.5	34.5	4.2	0.14	No opinion
	12 weeks to 6 months	59.7	14.3	21.8	4.2	0.20	No opinion
	6 months	68.1	6.7	19.3	5.9	0.14	No opinion
Jogging on road	6 weeks	1.7	13.4	78.2	6.7	< 0.01	Not recommended
	6–12 weeks	22.7	27.7	44.5	5.0	< 0.01	Not recommended
	12 weeks to 6 months	51.3	14.3	27.7	6.7	0.63	No opinion
	6 months	59.7	10.1	22.7	7.6	0.76	No opinion
Running	6 weeks	10.1	84.0	5.9	0.0	< 0.01	Not recommended
	6–12 weeks	13.4	25.2	56.3	5.0	0.14	No opinion
	12 weeks to 6 months	38.7	22.7	33.6	5.0	0.14	No opinion
	6 months	51.3	15.1	26.9	6.7	0.78	No opinion
Running on treadmill	6 weeks	1.7	14.3	76.5	7.6	< 0.01	Not recommended
	6–12 weeks	17.6	30.3	47.1	5.0	< 0.01	Not recommended
	12 weeks to 6 months	45.4	22.7	26.9	5.0	0.93	No opinion
	6 months	53.8	16.0	22.7	7.6	0.76	No opinion
Mountain biking/incline cycling	6 weeks	4.2	18.5	66.4	10.9	0.04	Not recommended
	6–12 weeks	17.6	26.9	48.7	6.7	< 0.01	Not recommended
	12 weeks to 6 months	40.3	28.6	23.5	7.6	0.91	No opinion
	6 months	52.9	25.2	12.6	9.2	0.02	Recommended
Cycling on level ground	6 weeks	21.8	30.3	39.5	8.4	< 0.01	Not recommended
	6–12 weeks	54.6	24.4	16.8	4.2	0.01	Recommended
	12 weeks to 6 months	72.3	18.5	3.4	5.9	< 0.01	Recommended
	6 months	75.6	14.3	2.5	7.6	< 0.01	Recommended
Static cycling	6 weeks	63.9	23.5	6.7	5.9	< 0.01	Recommended
	6–12 weeks	79.8	15.1	3.4	1.7	< 0.01	Recommended
	12 weeks to 6 months	87.4	6.7	5.9	0.0	< 0.01	Recommended
	6 months	86.6	6.7	6.7	0.0	< 0.01	Recommended

Straat et al. were not real sports, but activities of daily living [17]. Therefore, comparison with the current study is not possible.

In 1999, Healy et al. published a survey conducted in the American Knee Society [4]. Fifty-eight members responded to a survey involving 42 sports and recommended the following: low-impact aerobics, stationary cycling, bowling, golf, dancing, horseback riding, croquet, walking, swimming, shooting, shuffleboard, and horseshoes. The following sports for 'allowed for the experienced patient' were only: road cycling, canoeing, hiking, rowing, cross-country skiing, stationary skiing, speed walking, tennis, weight machines, and ice skating.

Table 2 Summary of recommendations for water sports

	Follow up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Swimming	6 weeks	45.4	31.9	19.3	3.4	0.04	Recommended
	6–12 weeks	74.8	21.8	2.5	0.8	< 0.01	Recommended
	12 weeks to 6 months	90.8	5.0	4.2	0.0	< 0.01	Recommended
	6 months	89.9	4.2	5.9	0.0	< 0.01	Recommended
Aqua fitness	6 weeks	54.6	24.4	16.0	5.0	0.01	Recommended
	6–12 weeks	78.2	19.3	1.7	0.8	< 0.01	Recommended
	12 weeks to 6 months	90.8	3.4	5.9	0.0	< 0.01	Recommended
	6 months	89.9	3.4	6.7	0.0	< 0.01	Recommended
Surfing	6 weeks	1.7	5.0	83.2	10.1	< 0.01	Not recommended
	6–12 weeks	7.6	11.8	72.3	8.4	< 0.01	Not recommended
	12 weeks to 6 months	20.2	28.6	42.9	8.4	< 0.01	Not recommended
	6 months	33.6	34.5	21.0	10.9	0.93	No opinion
Windsurfing	6 weeks	1.7	6.7	80.7	10.9	< 0.01	Not recommended
	6–12 weeks	7.6	14.3	68.9	9.2	0.02	Not recommended
	12 weeks to 6 months	21.0	27.7	42.0	9.2	< 0.01	Not recommended
	6 months	33.6	36.1	19.3	10.9	0.76	No opinion
Sailing	6 weeks	3.4	17.6	68.9	10.1	0.01	Not recommended
	6–12 weeks	19.3	29.4	44.5	6.7	< 0.01	Not recommended
	12 weeks to 6 months	41.2	37.8	13.4	7.6	0.01	Recommended
	6 months	63.9	26.1	1.7	8.4	< 0.01	Recommended
Rowing	6 weeks	8.4	15.1	63.9	12.6	0.06	No opinion
	6–12 weeks	21.0	31.9	37.8	9.2	< 0.01	Not recommended
	12 weeks to 6 months	46.2	23.5	17.6	12.6	0.76	No opinion
	6 months	61.3	21.0	5.0	12.6	< 0.01	Recommended
Canoeing	6 weeks	5.0	10.1	72.3	12.6	< 0.01	Not recommended
	6–12 weeks	17.6	21.8	50.4	10.1	0.10	No opinion
	12 weeks to 6 months	40.3	27.7	21.0	10.9	0.93	No opinion
	6 months	53.8	26.9	7.6	11.8	< 0.01	Recommended
Kayaking	6 weeks	4.2	9.2	73.1	13.4	< 0.01	Not recommended
	6–12 weeks	16.8	21.8	51.3	10.1	0.14	No opinion
	12 weeks to 6 months	39.5	27.7	21.0	11.8	0.93	No opinion
	6 months	50.4	31.1	6.7	11.8	< 0.01	Recommended

In 2009, Swanson et al. conducted a similar survey among the members of the American Association for Hip and Knee Surgeons (AAHKS) [18]. Of 657 members, 139 responded to the survey that covered 15 sports. More than 80% of the AAHKS surgeons stated that swimming, walking on level ground, golf, cycling, stair climbing and walking on uneven ground may be practiced in an unlimited manner. Approximately 80% and more recommended not doing jogging, difficult alpine skiing, or sprint running. It is regarded as an interesting detail that AAHKS surgeons who performed large numbers of revision arthroplasty were significantly more liberal in their recommendations.

When comparing the 1999 American Knee Society recommendations and the 2009 AAHKS recommendations with the 2020 EKA recommendations, the following aspects come to mind: Although the major sports disciplines remain popular over centuries, some more trendy disciplines were introduced in the recent year. Therefore, these were also included in the current EKA recommendations (e.g., yoga and cross training). Apart from the time

Table 3 Summary of recommendations for mountaineering activities

	Follow-up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Hiking	6 weeks	13.4	16.8	57.1	12.6	0.76	No opinion
	6–12 weeks	36.1	24.4	30.3	9.2	0.10	No opinion
	12 weeks to 6 months	58.8	21.8	8.4	10.9	< 0.01	Recommended
	6 months	69.7	15.1	5.0	10.1	< 0.01	Recommended
Nordic walking	6 weeks	16.0	24.4	46.2	13.4	0.06	No opinion
	6–12 weeks	40.3	26.9	22.7	10.1	0.93	No opinion
	12 weeks to 6 months	63.0	18.5	5.9	12.6	< 0.01	Recommended
	6 months	66.4	19.3	0.8	13.4	< 0.01	Recommended
Climbing	6 weeks	0.8	14.3	75.6	9.2	< 0.01	Not recommended
	6–12 weeks	9.2	24.4	57.1	9.2	0.78	No opinion
	12 weeks to 6 months	33.6	31.9	26.9	7.6	0.63	No opinion
	6 months	47.1	26.9	16.0	10.1	0.20	No opinion
Canyoning	6 weeks	1.7	10.9	72.3	15.1	< 0.01	Not recommended
	6–12 weeks	9.2	17.6	63.0	10.1	0.27	No opinion
	12 weeks to 6 months	34.5	24.4	30.3	10.9	0.04	Not recommended
	6 months	43.7	22.7	21.0	12.6	0.78	No opinion

Table 4 Summary of recommendations for winter sports

	Follow up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Skiing	6 weeks	9.2	79.8	10.9	0.0	< 0.01	Not recommended
	6–12 weeks	5.9	21.0	65.5	7.6	0.27	No opinion
	12 weeks to 6 months	41.2	37.8	10.9	10.1	0.29	No opinion
	6 months	41.2	37.8	10.9	10.1	0.01	Recommended
Cross-country skiing/ Nordic skiing	6 weeks	0.8	9.2	77.3	12.6	< 0.01	Not recommended
	6–12 weeks	10.9	21.0	59.7	8.4	0.93	No opinion
	12 weeks to 6 months	33.6	29.4	24.4	12.6	0.29	No opinion
	6 months	43.7	30.3	10.9	15.1	0.20	No opinion
Snowboarding	6 weeks	5.9	83.2	10.9	0.0	< 0.01	Not recommended
	6–12 weeks	5.0	11.8	74.8	8.4	< 0.01	No opinion
	12 weeks to 6 months	22.7	24.4	41.2	11.8	< 0.01	Not recommended
	6 months	31.9	28.6	26.1	13.4	0.10	No opinion
Ice skating/skating	6 weeks	0.8	5.0	83.2	10.9	< 0.01	Not recommended
	6–12 weeks	5.0	12.6	73.9	8.4	< 0.01	Not recommended
	12 weeks to 6 months	24.4	28.6	34.5	12.6	< 0.01	Not recommended
	6 months	34.5	37.0	16.0	12.6	0.48	No opinion
Tobogganing	6 weeks	0.8	4.2	77.3	17.6	< 0.01	Not recommended
	6–12 weeks	8.4	10.9	67.2	13.4	< 0.01	Not recommended
	12 weeks to 6 months	25.2	23.5	34.5	16.8	< 0.01	Not recommended
	6 months	38.7	25.2	17.6	18.5	0.39	No opinion

Table 5 Summary of recommendations for ball sports

	Follow-up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Tennis doubles	6 weeks	4.2	11.8	77.3	6.7	< 0.01	Not recommended
	6–12 weeks	17.6	26.9	52.1	3.4	< 0.01	Not recommended
	12 weeks to 6 months	44.5	32.8	17.6	5.0	0.04	Recommended
	6 months	63.0	23.5	7.6	5.9	< 0.01	Recommended
Tennis singles	6 weeks	1.7	9.2	81.5	7.6	< 0.01	Not recommended
	6–12 weeks	9.2	16.8	69.7	4.2	0.20	No opinion
	12 weeks to 6 months	26.9	34.5	31.9	6.7	0.14	No opinion
	6 months	41.2	28.6	22.7	7.6	0.76	No opinion
Golf	6 weeks	12.6	24.4	57.1	5.9	0.29	No opinion
	6–12 weeks	42.0	33.6	22.7	1.7	0.09	No opinion
	12 weeks to 6 months	69.7	20.2	5.0	5.0	< 0.01	Recommended
	6 months	82.4	10.1	1.7	5.9	< 0.01	Recommended
Squash	6 weeks	0.8	9.2	82.4	7.6	< 0.01	Not recommended
	6–12 weeks	10.1	12.6	70.6	6.7	0.04	Not recommended
	12 weeks to 6 months	20.2	29.4	42.0	8.4	< 0.01	Not recommended
	6 months	32.8	26.1	30.3	10.9	0.04	Not recommended
Badminton	6 weeks	0.8	9.2	79.0	10.9	< 0.01	Not recommended
	6–12 weeks	9.2	13.4	66.4	10.9	0.04	Not recommended
	12 weeks to 6 months	21.8	32.8	32.8	12.6	< 0.01	Not recommended
	6 months	39.5	26.9	19.3	14.3	0.78	No opinion
Table tennis	6 weeks	7.6	16.0	66.4	10.1	0.06	No opinion
	6–12 weeks	22.7	31.1	41.2	5.0	< 0.01	Not recommended
	12 weeks to 6 months	44.5	29.4	17.6	8.4	0.20	No opinion
	6 months	60.5	25.2	5.9	8.4	< 0.01	Recommended
Handball	6 weeks	5.9	84.9	9.2	0.0	< 0.01	Not recommended
	6–12 weeks	5.0	8.4	79.8	6.7	< 0.01	Not recommeded
	12 weeks to 6 months	15.1	13.4	63.0	8.4	0.48	No opinion
	6 months	20.2	16.8	51.3	11.8	0.29	No opinion
Volleyball	6 weeks	0.8	5.0	85.7	8.4	< 0.01	Not recommended
	6–12 weeks	5.0	9.2	79.8	5.9	< 0.01	No opinion
	12 weeks to 6 months	14.3	15.1	61.3	9.2	0.61	Not recommended
	6 months	21.8	18.5	47.9	11.8	0.06	No opinion
Soccer/football	6 weeks	5.0	87.4	7.6	0.0	< 0.01	Not recommended
	6–12 weeks	3.4	9.2	81.5	5.9	< 0.01	Not recommended
	12 weeks to 6 months	12.6	14.3	65.5	7.6	0.27	No opinion
	6 months	17.6	17.6	54.6	10.1	0.50	No opinion
Basketball	6 weeks	5.0	86.6	8.4	0.0	< 0.01	Not recommended
	6–12 weeks	4.2	9.2	80.7	5.9	< 0.01	Not recommended
	12 weeks to 6 months	13.4	16.0	63.0	7.6	0.61 < 0.01	No opinion
	6 months	18.5	18.5	52.9	10.1	0.29	No opinion

recommendations, also cultural differences exist between e.g., North America and Europe regarding the variety of sports usually performed (e.g., throwing horseshoes). Moreover, the EKA survey also covered different postoperative time frames. When it comes to inter-cultural differences, it is striking that Danish surgeons made the most

Table 6 Summary of recommendations for contact sports

	Follow-up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Tai Chi	6 weeks	15.1	30.3	41.2	13.4	< 0.01	Not recommended
	6–12 weeks	42.0	22.7	26.9	8.4	0.50	No opinion
	12 weeks to 6 months	54.6	18.5	15.1	11.8	0.27	No opinion
	6 months	60.5	19.3	7.6	12.6	0.01	Recommended
Full contact sports (e.g., boxing)	6 weeks	4.2	87.4	8.4	0.0	< 0.01	Not recommended
	6–12 weeks	4.2	10.9	79.0	5.9	< 0.01	Not recommended
	12 weeks to 6 months	12.6	13.4	66.4	7.6	0.20	No opinion
	6 months	15.1	21.8	52.9	10.1	0.29	No opinion
Martial arts	6 weeks	0.8	6.7	81.5	10.9	< 0.01	Not recommended
	6–12 weeks	4.2	12.6	75.6	7.6	< 0.01	Not recommended
	12 weeks to 6 months	11.8	16.0	62.2	10.1	0.37	No opinion
	6 months	16.8	19.3	52.1	11.8	0.39	No opinion

Table 7 Summary of recommendations for fitness training

	Follow-up	Allowed	Allowed if experienced	Not allowed	No opinion	*P* value	Recommendation
Fitness/weight lifting	6 weeks	7.6	26.1	58.0	8.4	0.78	No opinion
	6–12 weeks	27.7	32.8	34.5	5.0	0.10	No opinion
	12 weeks to 6 months	45.4	31.9	16.0	6.7	0.04	Recommended
	6 months	57.1	21.8	13.4	7.6	0.01	Recommended
Cross training	6 weeks	5.0	9.2	75.6	10.1	< 0.01	Not recommended
	6–12 weeks	13.4	25.2	54.6	6.7	0.14	No opinion
	12 weeks to 6 months	31.9	28.6	30.3	9.2	0.10	No opinion
	6 months	40.3	26.9	21.8	10.9	0.93	No opinion
Yoga	6 weeks	18.5	31.9	43.7	5.9	< 0.01	Not recommended
	6–12 weeks	45.4	32.8	18.5	3.4	0.02	Recommended
	12 weeks to 6 months	68.1	20.2	5.9	5.9	< 0.01	Recommended
	6 months	78.2	13.4	1.7	6.7	< 0.01	Recommended
Aerobics	6 weeks	6.7	26.1	58.8	8.4	0.93	No opinion
	6–12 weeks	31.9	32.8	30.3	5.0	0.50	No opinion
	12 weeks to 6 months	57.1	30.3	6.7	5.9	< 0.01	Recommended
	6 months	72.3	16.8	3.4	7.6	< 0.01	Recommended

liberal recommendations to their patients [9]. According to those authors, Danish surgeons allowed significantly more types of sports than their colleagues from the United States.

Ojaca et al., Fawaz et al. and Boettner et al. also published in the field of sports recommendations after TKA [1, 2, 12]. However, those two articles did not elaborate recommendations themselves but reviewed the findings of the aforementioned studies.

Apart from the matter of experts' recommendations on sports following TKA, the question arises whether implant wear and loosening might be accelerated by different kinds of sports. In this regard, Ponzio et al. investigated the outcome of physically active and inactive patients by conducting a retrospective analysis of an institutional arthroplasty registry over six years [13]. Active patients were matched with inactive patients (1.008 patients in each group) and revision procedures were then analyzed. A significantly increased revision rate (all reasons) was found among physically active patients (3.2% vs. 1.6% for 5–10 years). Similarly, Valle et al. retrospectively compared 88 athletic TKA patients and 42 inactive patients [19]. Twelve years postoperative, the revision rate was significantly higher among inactive patients (23.8% vs. 15.2%). Jones et al. compared 26 patient pairs (inactive and active) regarding revision rates [8]. According to the authors, doing sports after TKA was

Table 8 Summary of recommendations for miscellaneous physical activities

	Follow up	Allowed (%)	Allowed when experienced (%)	Not allowed (%)	No opinion (%)	z test *P* value	Recommendation
Horseback riding	6 weeks	1	23	75	2	0.001	Not recommended
	6–12 weeks	17	37	45	1	0.15	Undecided
	12 weeks to 6 months	43	38	17	2	0.001	Recommended
	6 months	62	31	5	2	0.001	Recommended
Extreme sports	6 weeks	0	5	92	3	0.001	Not recommended
	6–12 weeks	4	8	86	3	0.001	Not recommended
	12 weeks to 6 months	11	12	74	3	0.03	Not recommended
	6 months	16	13	67	4	0.93	Undecided
Dancing	6 weeks	9	24	65	2	0.001	Not recommended
	6–12 weeks	37	36	26	1	0.001	Recommended
	12 weeks to 6 months	59	34	7	0	0.001	Recommended
	6 months	81	16	4	0	0.001	Recommended
Bowling	6 weeks	10	20	67	3	0.001	Not recommended
	6–12 weeks	29	31	39	1	0.15	Undecided
	12 weeks to 6 months	54	30	15	1	0.001	Recommended
	6 months	74	18	7	1	0.001	Recommended

not associated with a higher risk for revision arthroplasty. Thus, the issue of durability of TKA among athletic patients seems to be a field without absolute consensus. At any rate, potential effects of sports on wear and loosening have to be weighed against positive effects on cardiovascular fitness [7]. Furthermore, the improvements made over time in the polyethylene used in knees were also not taken into account.

Shared decision-making (SDM) is a strongly endorsed approach, in which patients and clinicians work together to formulate a sensible care plan [15]. Shared decision-making (SDM) describes the work that patients and clinicians do together to jointly draw up a sensible treatment plan that corresponds well to the patient's situation [15]. For the discussion with the patient about the physical activities, it is important to inform the patient about the opinion of specialized surgeons and also the periods recommended for a safe return to sports. This study offers surgeons and patients valuable insight here.

The following limitations of the study are acknowledged. First, data from only one arthroplasty society were obtained. Second, it should be stated that a survey study does not fulfill the criteria for strong scientific evidence. Third, for the sake of data homogeneity, we focused only on TKA. Consequently, no conclusions can be drawn for unicompartmental or revision knee arthroplasty.

Strengths of the current study are the fact that for the first time, the issue of sports recommendations following TKA was investigated with a comprehensive questionnaire covering 47 sports and the fact that the survey was conducted in a dedicated Europe-wide knee arthroplasty society. Another strength of this study is the fact that most survey participants had personal experience with sports (60.2% did a sport more than twice a week). Moreover, for the first time, also different postoperative time frames were investigated. In addition, the current recommendations cover the majority of today's sports. The older abovementioned surveys may not always reflect the whole range of sports practiced nowadays. Apart from the time recommendations, also cultural differences exist between e.g., North America and Europe regarding the variety of sports usually performed.

The current study is also deemed to be clinically relevant. Based on (1) the strong expertise of the survey participants, (2) the broad dataset including 47 sports and (3) the multinational approach of the survey and (4) the consideration of specific postoperative time frames, the results of the study may serve as a robust foundation for making recommendations in daily clinical practice.

Conclusions

The number of sports recommended by EKA surgeons increases stepwise over the postoperative periods. The data presented here may serve as a basis for answering patient questions on timing and giving recommendations for returning to sports following standard primary TKA and should be individualized by surgeons for their patients' expectations and goals.

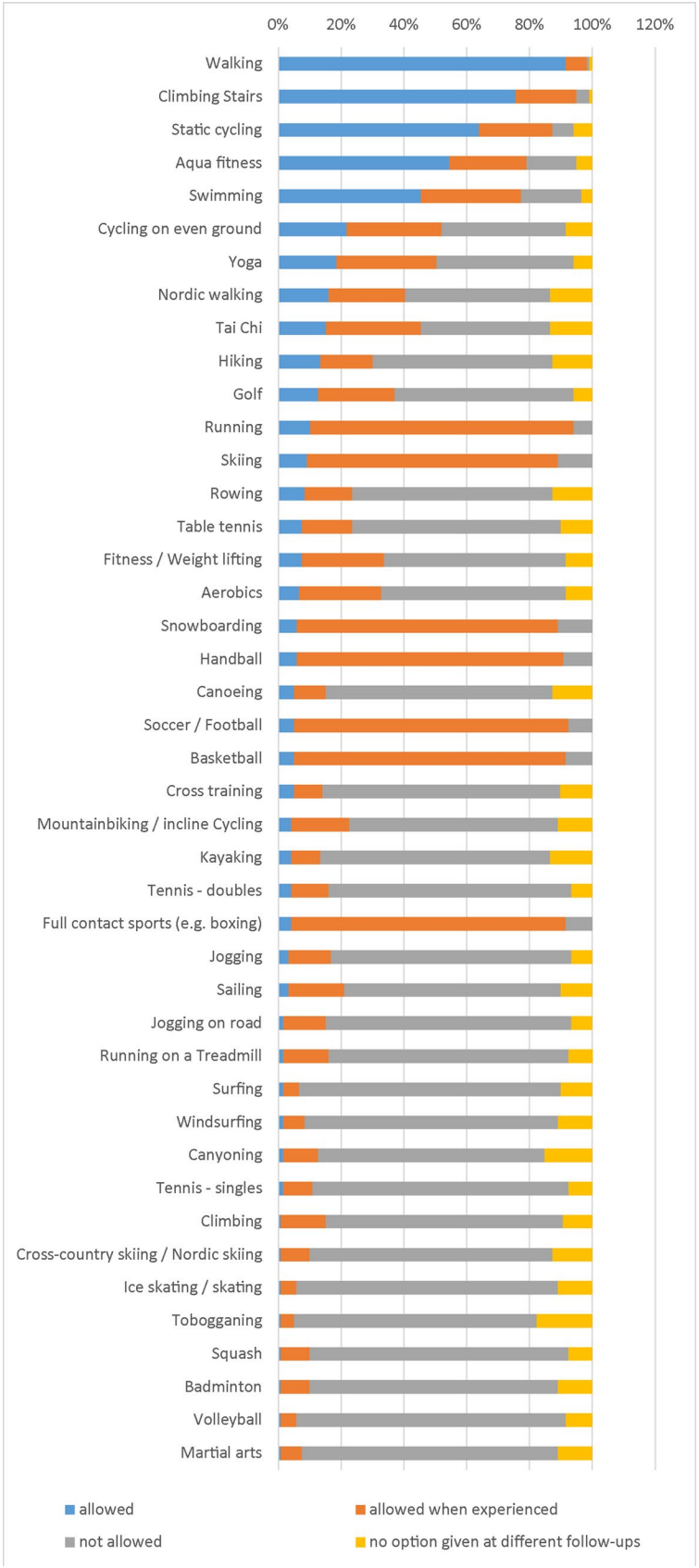

Fig. 6 Visualization of sports and recommendations after 6 weeks

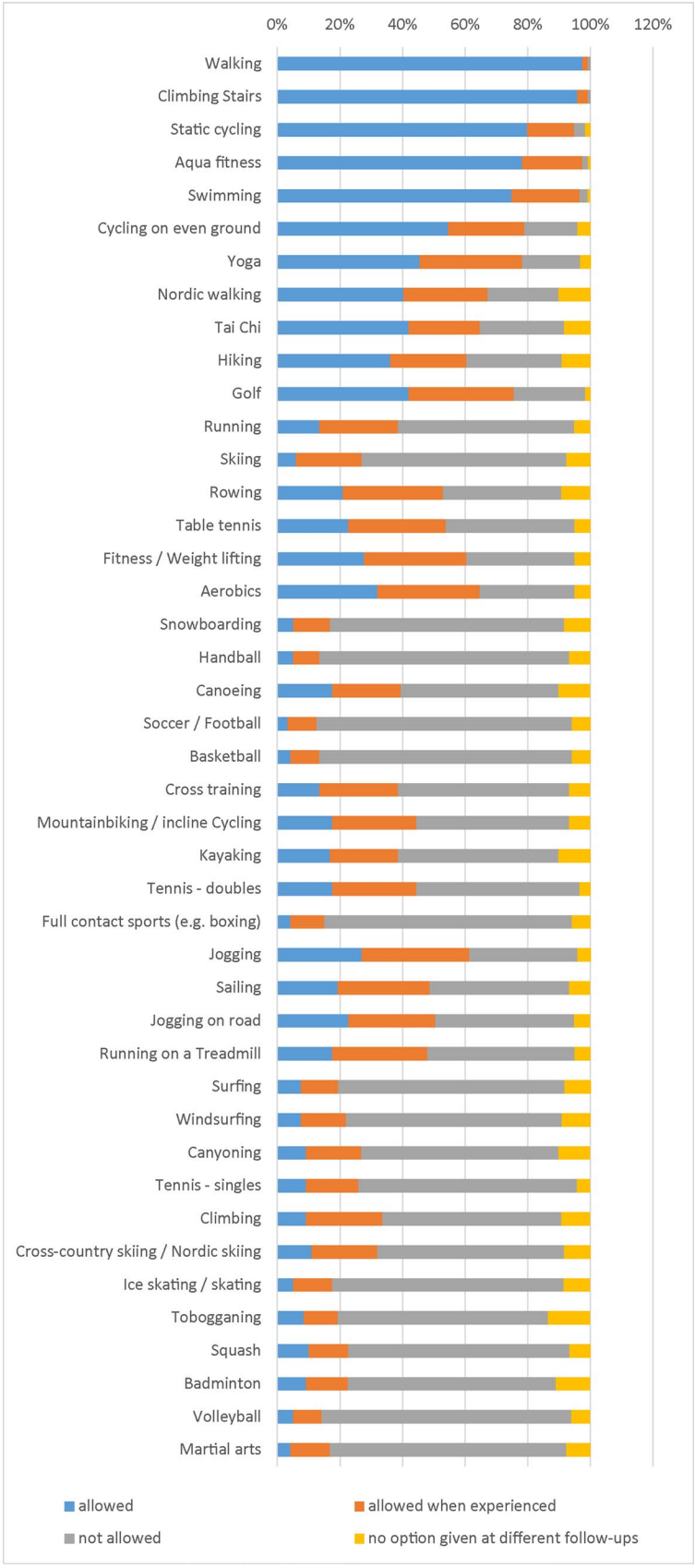

Fig. 7 Visualization of sports and recommendations after 6–12 weeks

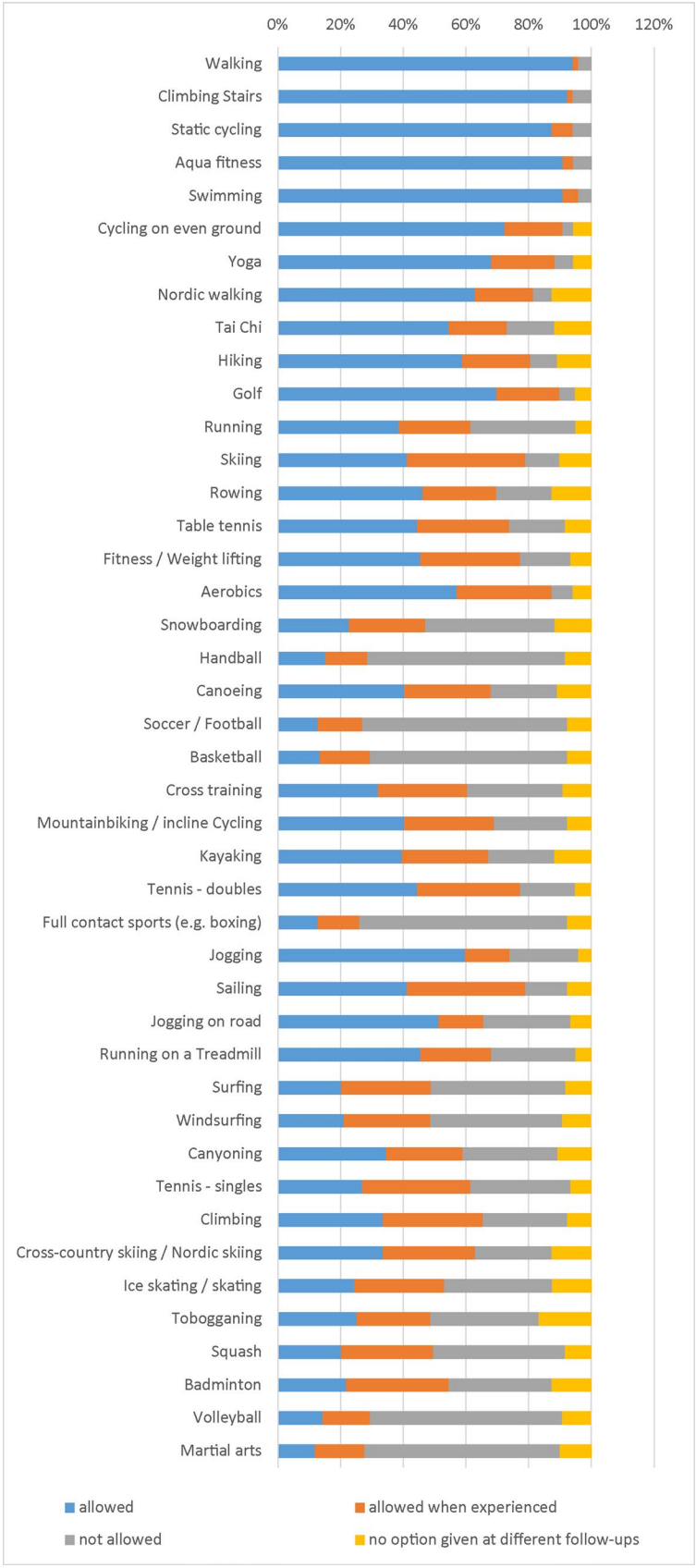

Fig. 8 Visualization of sports and recommendations after 12 weeks to 6 months

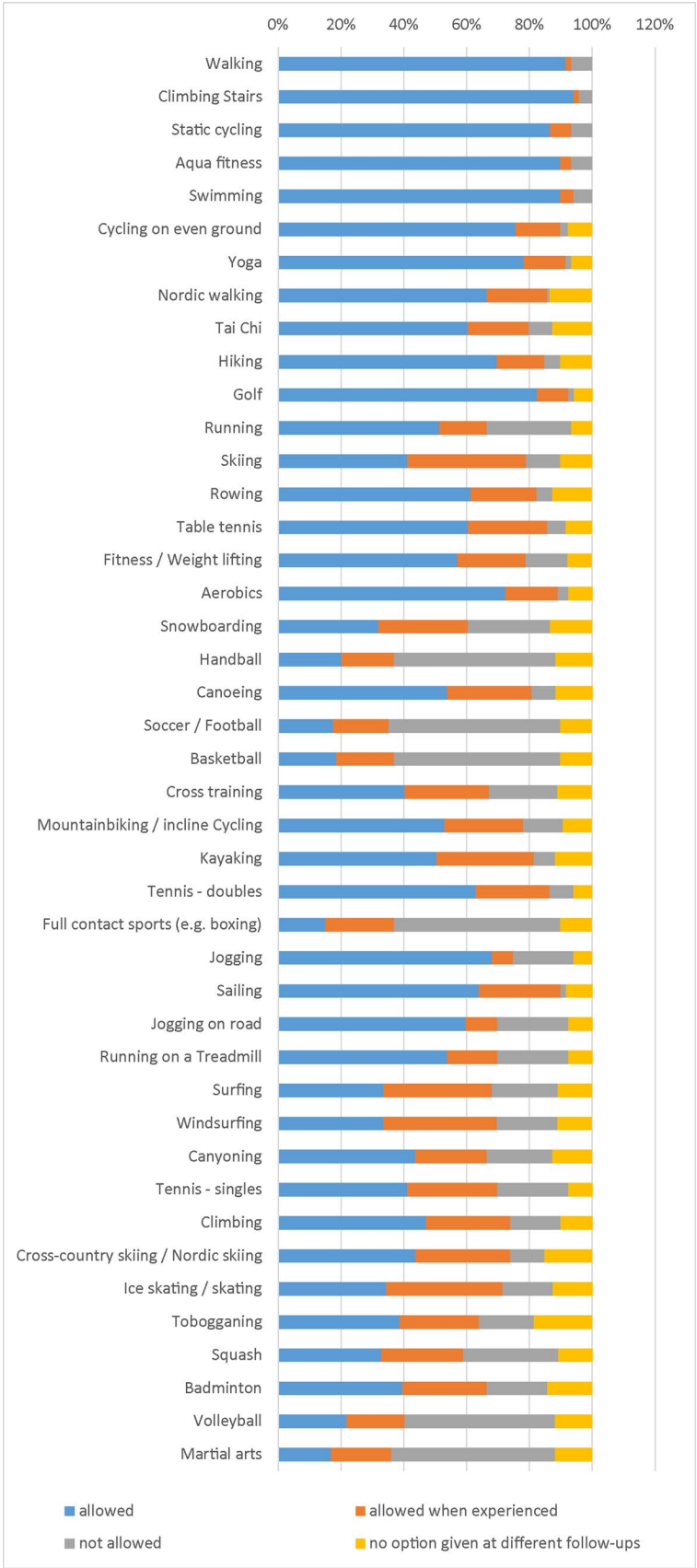

Fig. 9 Visualization of sports and recommendations after more than 6 months

Funding No funding was available for this study.

Compliance with ethical standards

Conflict of interest The authors declare that no conflicts of interests.

Ethical approval The subject was not submitted for ethical committee approval due to the fact that neither clinical data nor patients were involved.

References

1. Boettner F, Kasparek M, Rueckl K et al (2017) Sport nach Knie- und Hüftendoprothetik. Sportverletz Sportschaden 31:207–212
2. Fawaz WS, Masri BA (2020) Allowed activities after primary total knee arthroplasty and total hip arthroplasty. Orthop Clin North Am 51:441–452
3. Hanreich C, Martelanz L, Koller U et al (2020) Sport and physical activity following primary total knee arthroplasty: a systematic review and meta-analysis. J Arthroplasty 35:2274-2285.e1
4. Healy WL, Iorio R, Lemos MJ (2001) Athletic activity after joint replacement. Am J Sports Med 29:377–388
5. Healy WL, Sharma S, Schwartz B et al (2008) Athletic activity after total joint arthroplasty. J Bone Joint Surg Am 90:2245–2252
6. Hepperger C, Gföller P, Abermann E et al (2018) Sports activity is maintained or increased following total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 26:1515–1523
7. Jones DL (2011) A public health perspective on physical activity after total hip or knee arthroplasty for osteoarthritis. Phys Sportsmed 39:70–79
8. Jones DL, Cauley JA, Kriska AM et al (2004) Physical activity and risk of revision total knee arthroplasty in individuals with knee osteoarthritis: a matched case-control study. J Rheumatol 31:1384–1390
9. Laursen MK, Andersen JB, Andersen MM et al (2014) Danish surgeons allow the most athletic activities after total hip and knee replacement. Eur J Orthop Surg Traumatol 24:1571–1577
10. McGrory BJ, Stuart MJ, Sim FH (1995) Participation in sports after hip and knee arthroplasty: review of literature and survey of surgeon preferences. Mayo Clin Proc 70:342–348
11. Meester SB, Wagenmakers R, van den Akker-Scheek I, Stevens M (2018) Sport advice given by Dutch orthopaedic surgeons to patients after a total hip arthroplasty or total knee arthroplasty. PLoS ONE 13:e0202494
12. Oljaca A, Vidakovic I, Leithner A, Bergovec M (2018) Current knowledge in orthopaedic surgery on recommending sport activities after total hip and knee replacement. Acta Orthop Belg 84:415–422
13. Ponzio DY, Chiu Y-F, Salvatore A et al (2018) An analysis of the influence of physical activity level on total knee arthroplasty expectations, satisfaction, and outcomes: increased revision in active patients at five to ten years. J Bone Joint Surg Am 100:1539–1548
14. Price AJ, Alvand A, Troelsen A et al (2018) Knee replacement. Lancet 392:1672–1682
15. Riddle DL, Sando T, Tarver T et al (2020) Shared decision making applied to knee arthroplasty: a systematic review of randomized trials. Arthritis Care Res. https://doi.org/10.1002/acr.24240
16. Stenner BJ, Mosewich AD, Buckley JD (2019) Why do older adults play golf? an evaluation of factors related to golf participation by older adults. J Aging Phys Act 28:399–405
17. Straat AC, Coenen P, Smit DJM et al (2020) Development of a personalized m/ehealth algorithm for the resumption of activities of daily life including work and sport after total and unicompartmental knee arthroplasty: a multidisciplinary delphi study. Int J Environ Res Public Health 17(14):4952
18. Swanson EA, Schmalzried TP, Dorey FJ (2009) Activity recommendations after total hip and knee arthroplasty: a survey of the American Association for Hip and Knee Surgeons. J Arthroplasty 24:120–126
19. Valle C, Sperr M, Lemhöfer C et al (2017) Does sports activity influence total knee arthroplasty durability? analysis with a follow-up of 12 years. Sportverletz Sportschaden 31:111–115
20. Waldstein W, Kolbitsch P, Koller U et al (2017) Sport and physical activity following unicompartmental knee arthroplasty: a systematic review. Knee Surg Sports Traumatol Arthrosc 25:717–728