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MINIREVIEWS

Physical activity after total knee arthroplasty: A critical review

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Abstract

Total knee arthroplasty (TKA) is the most commonly performed elective surgery in the United States. TKA typically improves functional performance and reduces pain associated with knee osteoarthritis. Little is known about the influence of TKA on overall physical activity levels. Physical activity, defined as "any bodily movement produced by skeletal muscles that results in energy expenditure", confers many health benefits but typically decreases with endstage osteoarthritis. The purpose of this review is to describe the potential benefits (metabolic, functional, and orthopedic) of physical activity to patients undergoing TKA, present results from recent studies aimed to determine the effect of TKA on physical activity, and discuss potential sources of variability and conflicting results for physical activity outcomes. Several studies utilizing self-reported outcomes indicate that patients perceive themselves to be more physically active after TKA than they were before surgery. Accelerometry-based outcomes indicate that physical activity for patients after TKA remains at or below pre-surgical levels. Several different factors likely contributed to these variable results, including the use of different instruments, duration of follow-up, and characteristics of the subjects studied. Comparison to norms, however, suggests that daily physical activity for patients following TKA may fall short of healthy age-matched controls. We propose that further study of the relationship between TKA and physical activity needs to be performed using accelerometry-based outcome measures at multiple post-surgical time points.

Key words: Physical activity; Knee osteoarthritis; Self-report; Total knee arthroplasty; Accelerometer

Core tip: Little is known about the influence of total knee arthroplasty (TKA) on physical activity levels.

This review describes the potential benefits of physical activity to patients undergoing TKA, presents results from recent studies aimed to determine the effect of TKA on physical activity, and discusses potential sources of variability and conflicting results for physical activity outcomes. Several studies indicate that patients describe themselves to be more physically active after TKA than before surgery. Accelerometry-based outcomes indicate that physical activity for patients after TKA may remain at or below pre-surgical levels. Daily physical activity for patients following TKA may fall short of healthy age-matched controls.

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INTRODUCTION

Total knee arthroplasty (TKA) is the most commonly performed elective surgery in the United States for the relief of pain associated with osteoarthritis (OA)[1,2]. A central issue in patients with OA is reduced level of physical activity. TKA is successful for decreasing pain and increasing functional performance, but less is known about the influence of TKA on restoring overall physical activity levels[3-5]. Physical activity, defined as "any bodily movement produced by skeletal muscles that results in energy expenditure", confers many health benefits but typically decreases with endstage OA[6,7]. The purpose of this review is to describe the potential benefits of physical activity to patients undergoing TKA, present results from recent studies aimed to determine the effect of TKA on physical activity, and discuss potential sources of variability and conflicting results for physical activity outcomes.

The positive effects of physical activity are particularly important to patients undergoing TKA, as OA predisposes these individuals to metabolic and functional decline[1,8,9]. This decline may be protected against and/or remediated by physical activity[10-14]. For example, OA confers an increased risk of insulin resistance [odds ratio (OR) = 1.18 normal weight, 1.34 obese] and progression from insulin resistance to type two diabetes mellitus (OR = 2.18)[8,15]. Higher levels of physical activity are associated with reduced risk of metabolic disease, and interventions aimed to increase physical activity may improve metabolic outcomes[15,16]. Healthy metabolic function may be bolstered by physical activity in patients with knee OA, as indicated by higher levels of physical activity conferring an odds ratio of 0.45 for metabolic syndrome[17].

Functional performance strongly influences quality of life and is limited by OA and following TKA[18-20]. Though physical activity does not directly represent functional performance, limitations in functional performance may be improved by increased physical activity. Walking speed, an indicator of functional capacity, has been shown to improve in a population of people with knee OA after exercise aimed at increasing daily physical activity[21]. Little is known about the effect of physical activity on functional performance following TKA, but any potential relationship could be important as functional performance is chronically limited after TKA as compared to healthy adults. In spite of the potential limitations posed by the functional performance deficits present after TKA, treatments aimed to increase physical activity are of particular interest as they may actually ameliorate these functional performance deficits[22].

Physical activity appears to provide a protective effect against OA as demonstrated by a recent systematic review of the literature. This finding is likely related to the positive effect of physical activity on the maintenance of cartilage[23]. More physical activity is not only associated with greater tibial cartilage volume, but also fewer cartilage defects[24]. Although we are unaware of any studies investigating this association in patients with OA, this population could reasonably expect to derive similar benefits from physical activity.

In summary, patients suffering from OA are at increased risk of metabolic, functional, and orthopaedic dysfunction. Overwhelming agreement exists regarding the positive effects of physical activity on these issues. With these benefits in mind, characterization of physical activity levels after TKA is of great importance to promote optimal health and function, but little is known about the relationship of TKA and physical activity.

RESEARCH

This review encompasses results from searches performed in PubMed, Ovid Medline, and Web of Science. Search terms used were: TKA, total knee replacement, and physical activity, daily steps, and activity counts. No delimiters were used regarding date of publication. Studies in which patients undergoing TKA were present as a discrete subgroup were included. Intervention (*i.e.*, not including counseling or encouragement to increase the amount of physical activity performed) studies that determined the effect of TKA on patients' physical activity were excluded *a priori*, as were investigations addressing other types of knee surgery, including revision arthroplasty, and TKA subsequent to conditions other than OA (*e.g.*, hemophilia, acute infection). Since 2002, 18 published studies meeting our selection parameters have examined the relationship between TKA and physical activity (Tables 1 and 2)[25-42]. Five of the studies explicitly note recruiting OA patients undergoing TKA[25,26,29,34,37], while the remaining studies do not indicate the underlying conditions leading to TKA. We assumed that the majority of the individuals

Table 1 Summary of studies

Ref.	Study type	Assessment type	Assessment(s)	Duration of follow-up	Physical activity findings
Bauman *et al*[39]	Cross-sectional	Self-Report Questionnaire	UCLA	1 yr	Engage in moderate to high levels
Bonnin *et al*[41]	Cross-sectional	Self-Report Questionnaire	Perception	Mean = 44 mo	Mixed results
Brandes *et al*[25]	Longitudinal	Accelerometry	Activity Monitor (McRoberts; SAM, OrthoCare Innovations)	12-mo	Increase
Chatterji *et al*[42]	Cross-sectional	Self-Report Questionnaire	Grimby's Scale	1-2 yr	Engage in moderate levels
de Groot *et al*[26]	Longitudinal	Self-Report Questionnaire, Accelerometry	PASIPD, Activity Monitor (IDEEA)	6 mo	Self-report: Increase Accelerometry: No change
Franklin *et al*[27]	Longitudinal	Accelerometry	Activity Monitor (SAM, OrthoCare Innovations)	6 mo	Decrease
Hayes *et al*[28]	Longitudinal	Accelerometry	Activity Monitor (IDEEA)	6 wk, 3 mo, 6 mo, 12 mo	No change
In *et al*[38]	Longitudinal	Self-Report Questionnaire	LEAS	2 yr	Increase
Jones *et al*[29]	Longitudinal	Self-Report Questionnaire	Historical Leisure Activity Questionnaire	12 mo	Increase
Kersten *et al*[30]	Cross-sectional	Self-Report Questionnaire	Short Questionnaire to Assess Health Enhancing Physical Activity	1 to 5 yr	Less than healthy older adults
Krenk *et al*[31]	Longitudinal	Accelerometry	Activity Monitor (Actiwatch, Philips Respironics)	4 d, 6 d	Decrease
Lachiewicz *et al*[32]	Longitudinal	Self-Report Questionnaire	LEAS	1 yr, 2 yr	Increase
Meding *et al*[33]	Cross-sectional	Self-Report Questionnaire	UCLA	20 yr	
Tsonga *et al*[34]	Longitudinal	Self-Report Questionnaire, Accelerometry	PASE, Activity Monitor (Digiwalker, Yamax)	3-6 mo	Increase
Vaidya *et al*[35]	Longitudinal	Self-Report Questionnaire	LEAS	1 yr	Increase
Vissers *et al*[37]	Longitudinal	Accelerometry	Activity Monitor (Rotterdam Activity Monitor, Temec Instruments)	6 mo	No comparison performed
Vissers *et al*[36]	Longitudinal	Accelerometry	Activity Monitor (Rotterdam Activity Monitor, Temec Instruments)	6 mo, 4 yr	No change
Walker *et al*[40]	Longitudinal	Accelerometry	Activity Monitor (Numact)	3 mo, 6 mo	Increase

LEAS: Lower Extremity Activity Scale; PASE: Physical Activity Scale for the Elderly; UCLA: University of California Los angeles Physical Activity Questionnaire; PASIPD: Physical activity scale for individuals with physical disabilities.

Table 2 Outcome measure reliability and validity

Outcome measure	Reliability	Validity
Grimby's Scale	N/A	N/A
Historical Leisure Activity Questionnaire	r = 0.690-0.870[54,59]	r = 0.26[54]
LEAS	r = 0.9147[45]	r = 0.79[45]
PASE	ICC = 0.77[60]	r = 0.06-0.45[51]
PASIPD	r = 0.77[53]	r = 0.30[53]
Perception	N/A	N/A
Short Questionnaire to Assess Health Enhancing Physical Activity	r = 0.77[61]	r = 0.45[30]
UCLA	r = 0.86[49]	r = -0.50 – 0.51[62]
Activity Monitor	r^2 = 0.98[57]	r^2 = 0.91[56]

LEAS: Lower Extremity Activity Scale; PASE: Physical Activity Scale for the Elderly; PASIPD: Physical activity scale for individuals with physical disabilities.

participating in these investigations underwent surgery due to OA, as 95% of all TKAs in the United States are performed secondary to OA[25,29,34-37,43,44].

RESULTS

Longitudinal investigations

Thirteen of the studies in this review used longitudinal study designs. Of these thirteen studies, eight indicate that physical activity level is increased after TKA. However, physical activity level was measured exclusively by self-report questionnaire in four of the eight studies[29,32,35,38]. The Lower Extremity Activity Scale (LEAS), a self-report instrument developed by Saleh *et al*[45] to estimate physical activity in patients with lower limb dysfunction, was used in three of these investigations[32,35,38]. Vaidya *et al*[35] found mean LEAS scores (ranging from a minimally active zero to an extremely active 18) to increase from 6.7 pre-surgically to 11.3 (mean) one year after surgery (*P* values not provided). Increased LEAS scores were also found two years after TKA by In *et al*[38] [7.7 ± 2.1 to 10.3 ± 1.6 (mean ± SD), $P < 0.001$] and Lachiewicz and Lachiewicz [8.0 to 9.9 (mean), $P < 0.01$][32,38]. The final study to focus solely on self-report measures of physical activity used the Historical Leisure Activity Questionnaire (HLAQ)[29]. Median estimated MET-hours per week increased from 2.2 ± 12.4 before surgery to 10.8 ± 2.8 (mean ± SD) 12-mo after TKA ($P < 0.0005$), thereby exceeding the goal of 7.5 MET-hours per week of physical activity recommended by the United States Department of Health and Human Services[29,46]. Interestingly, this investigation also asked participants to rate how active they expected to be after surgery, which was significantly greater [23.3 ± 41.1 MET-hours per week (mean ± SD)] than the actual estimated activity levels achieved ($P < 0.05$).

Two longitudinal studies reporting increases in physical activity after TKA used questionnaires in combination with accelerometry-based measures. Tsonga *et al*[34] administered the Physical Activity Scale for the Elderly (PASE) in 52 older women undergoing TKA. The average PASE for healthy individuals aged 65 years or greater is 103 ± 64 (mean ± SD)[47]. In the group of women undergoing TKA, scores increased from a mean of 43.3 before surgery to 67.9 (mean) six months after surgery ($P < 0.01$)[34]. In addition to the PASE, accelerometer-based activity monitors were used to quantify physical activity. However, physical activity monitoring was performed only three (2693 ± 1368 steps/d) and six months after TKA, (3518 ± 1835 steps/d; mean ± SD), and not pre-surgically, so neither alterations in accelerometry-based measures of physical activity, nor their relation to self-assessed measures of physical activity, could be adequately assessed[34]. A comparison can be made to the healthy population, however, as data derived from NHANES suggest the average woman between the ages of 70 and 74 years takes between 2565 and 4250 steps/d[48]. de Groot *et al*[26], performed both self-reported assessments of physical activity in METs per hour per day (METs h/d) using the Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) and accelerometry-based measures, before and six months after TKA. Mean PASIPD scores increased from 9.5 at baseline to 17.9 METs h/d (mean) ($P = 0.01$) six months after TKA. However, accelerometry-based physical activity outcomes at three and six months after surgery were not different compared to those collected before surgery[26].

Finally, two investigations found increased physical activity after TKA using only accelerometry-based outcome measures[25,40]. Brandes *et al*[25] found significant increases in daily step count upon comparison of values collected prior to TKA to 12-mo follow-up [4993 ± 2170 to 5932 ± 2111, respectively (mean ± SD), ($P = 0.003$)][25]. Walker *et al*[40], using average amplitude of activity monitor displacement multiplied by steps per day as a surrogate for energy expenditure, found overall physical activity was increased by 79% ($P = 0.02$). This increase could have resulted from increased volume of physical activity, intensity of physical activity, or both.

In contrast to the eight studies that demonstrated increased physical activity subsequent to TKA, three longitudinal studies found no change in physical activity after TKA. These investigations used accelerometry-based measures. Vissers *et al*[36] found no difference in physical activity comparing pre-surgical values [9.4 ± 3.9, movement related physical activity, (% 24 h, mean ± SD)] to those collected six months (10.6 ± 3.5) and four years (9.6 ± 3.8) postoperatively[36]. Hayes *et al*[28] used a system consisting of five accelerometers (IDEEA, MiniSun, Fresno, CA) attached to patients with TKA to characterize percentage of time spent in various activities including sitting, standing, walk/step/transition, and lie/recline. There were no differences in percentage of time in walk/step/transition between pre-surgical values and those collected six weeks, three months, six months, and Twelve months after TKA, which translated to a lack of significant changes in estimated energy expenditure over time. A second study performed by Vissers *et al*[37] identified percentages of time spent in movement-related activity before and after surgery as 7.6 (3.8, 17.5) and 8.1 (3.2, 17.0) percent [mean (minimum; maximum)] in participant satisfied with their surgical outcomes and 7.3 (2.7, 17.3) and 9.8 (2.8, 18.8) percent in participants less satisfied with their surgical outcomes. No statistical comparison was made between time points[37].

Two studies comparing pre- *vs* post-surgical activity suggest that physical activity may decrease after TKA. These studies used accelerometry-based outcome measures exclusively. Krenk *et al*[31] investigated the short-term (baseline compared to four and six days post-surgery) effect of TKA and found physical activity to be decreased [209861 ± 55077 to 163007 ± 56093 and 186333 ± 71482 activity counts/day, respectively (mean ± SD)], though no formal statistical analysis was performed[31]. Franklin *et al*[27] found similar results [3822 ± 1459 to 2881 ± 1700 steps/d, respectively (mean ± SD)] between pre-surgery and six-months post-surgery, with no statistical comparisons performed.

Cross sectional investigations

Cross-sectional and comparative investigations have also been performed to examine the relationship between TKA and physical activity. Bauman *et al*[39] found the median university of california los angeles (UCLA) Physical Activity Score to be six for 184 participants tested one year after surgery. Meding *et al*[33] demonstrated a mean UCLA Physical Activity Score of 8.3 ± 1.2 (mean ± SD) 20 years after TKA. The results of this investigation using the UCLA Physical Activity Score indicate participation in moderate to high (*e.g.*, bicycling, golf) intensity physical activity in patients having undergone TKA. Another investigation used Grimby's Scale. One to two years after TKA, patients reported a score of 2.8 ± 1.1 (mean ± SD) representing a moderate amount of physical activity. A major limitation of these studies is that PA scores were only assessed post-operatively. No comparisons were made to pre-operative values, nor were comparisons with matched controlled groups performed. Bonnin *et al*[41] used a slightly different approach by asking patients having undergone TKA how active they perceive themselves to be after surgery as compared to before surgery, with 41.5% reporting increased, 29.0% reporting the same, 26.8% reporting decreased, and 2.7% not reporting levels of physical activity.

Comparisons to healthy populations

Comparisons of physical activity performed by patients undergoing TKA to healthy individuals have attempted to characterize potential deviations from physical activity norms. Kersten *et al*[30] investigated physical activity level using the Short Questionnaire to Assess Health Enhancing Physical Activity and found that compared to healthy older adults, patients with TKA engage in significantly fewer minutes of physical activity per week [1433 ± 1313, TKA; 1533 ± 1325, healthy adults (mean ± SD), P = 0.05]. Franklin *et al*[27] found patients with TKA aged 69 years (mean) took 2881 ± 1700 steps/d (mean ± SD) (a value equal to the daily steps taken by the age-matched approximately 25th percentile of men and approximately 35th percentile of women) 6 wk after surgery[27,48]. This finding aligns with the one study that compared physical activity levels of patients receiving TKA to normative age- and sex-matched controls. Mean amounts of physical activity at medium and high intensity were found to be approximately 20% less in patients after TKA than in the healthy population[30]. This finding is absolutely critical as it suggests that even if physical activity increases from pre- to post-TKA, these levels may still be less than healthy individuals. On the other hand, Brandes *et al*[25] found patients having undergone TKA (aged 66 ± 6 years) to take 5496 ± 1969 (mean ± SD) steps/d six months after surgery (approximately 50th percentile for age-matched men; approximately 70th percentile for age-matched women)[25,48]. Walker *et al*[40] assessed the physical activity of patients undergoing TKA as compared to healthy control participants. This study indicates that although physical activity was improved six months after TKA, it was still approximately 20% less than that performed by the control participants.

DISCUSSION

Our review of 18 published studies examining the relationship between TKA and physical activity indicates inconsistent findings. While eight longitudinal investigations (most relying on self-report outcome measures) found improvements in physical activity levels in patients undergoing TKA after surgery, two others found no difference, and three observed a decrease. Several different factors likely contributed to these variable results, including the use of different instruments, duration of follow-up, and characteristics of the subjects studied. Each of these is considered below.

Outcome measures

Variability in outcome measures likely contributed to mixed results. Available reliability and validity values for these outcome measures are presented in Table 2. Not only did outcome measures vary between self-report and accelerometry-based measures of physical activity, but methods of self-report varied by number of questions, timeframe of retrospective self-report, and type of activity assessed. The LEAS, for example is specifically tailored to patients with lower extremity dysfunction, and involves one question in which participants may rate their level of physical activity. The LEAS is generally deemed valid as reflected by correlation with pedometer measures[45]. Alternately, the PASE requires participants to recall the degree of physical activity in which they were involved during the previous week in 10 different areas. PASE scores take both type and volume of activity into account with possible scores ranging from 0 to 400. Several studies also used the UCLA Physical Activity Score. The UCLA Physical Activity Score is an instrument deemed to be valid in this population[49]. Participants are asked to rate their current activity level on a scale of one (which represents complete inactivity, dependence on others, and the inability to leave one's residence) to ten (which represents regular participation in "impact sports" such as jogging, ballet, and backpacking). Grimby's Scale, a less frequently used measure of physical activity, was also used for one study. In this self-reported scoring system, participation in physical activity ranges from one (hardly any physical activity) to six (regular, hard exercise)[42]. To our knowledge, Grimby's Scale has not been validated. When comparing patients having undergone TKA to healthy individuals, Kersten *et al*[30] utilized the Short Questionnaire to Assess Health Enhancing Physical Activity, which is moderately valid when compared to accelerometry-based measures[30,50]. This questionnaire examines days per week, average time per day, and intensity per session of walking and bicycling for both commuting and leisure. The most extensive self-report measure of physical activity found in these studies is the HLAQ. This assessment asks participants to recall their degree of participation (hours per week) and intensity in 36 leisure activities over the previous month. These results are subsequently translated as an estimate of MET-hours per week as an analog to kilocalories spent in physical activity normalized to body mass. Overall, the variability inherent in the different types of self-report instruments casts doubt on the ability to directly compare their results. Furthermore, all of these instruments rely on participant recall of physical activity participation, which has previously been shown to be problematic in individuals with TKA. For example, Bolszak *et al*[51] found the PASE to be poorly suited to patients undergoing TKA in terms of standard of error of measurement (32%-35%), smallest detectable change (89%-97%), and construct validity.

Concern regarding the validity of self-reported physical activity measures was recently raised by Prince *et al*[52] who performed a systematic review of studies examining both self-reported and direct measures of physical activity in adults. Self-reported measures' correlation to objective measures ranged from strong direct to strong indirect indicating poor overall agreement between recall of physical activity and accelerometry-based measurements of physical activity in a variety

Table 3 Patient characteristics by study

Ref.	*N*	Age at surgery (mean ± SD)	Body mass index (mean ± SD)	Sex distribution (M/F)	Comorbidities
Bauman *et al*[39]	184	66.4 ± 9.4	30.6 ± 7.9	76/108	Undisclosed
Bonnin *et al*[41]	347	74.8 (28-94)	27.9 ± 4.9	120/227	Undisclosed
Brandes *et al*[25]	53	65.8 ± 5.8	30.7 ± 4.1	19/34	Undisclosed
Chatterji *et al*[42]	144	70.8 ± 10.4	-	64/80	Undisclosed
de Groot *et al*[26]	44	62.1 ± 9.7	32.1 ± 5.3	20/24	Undisclosed
Franklin *et al*[27]	14	-	-	7/14	Undisclosed
Hayes *et al*[28]	65	61.1 ± 2.2	30.3 ± 2.8	5/7	Undisclosed
In *et al*[38]	169	66.7 (49-85)	26.4 ± 4.2	152/17	64 with metabolic syndrome, 40 with hypertension, 36 with diabetes, 13 with hypertension and diabetes
Jones *et al*[29]	90	66.5 ± 9.7	32.6 ± 7.2	36/54	Comorbidity Index of the American Academy of Orthopedic Surgeons Outcomes Data Collection Questionnaires = 0.9 ± 1.2
Kersten *et al*[30]	844	74.4 ± 11.9	29.4 ± 5.0	229/615	Undisclosed
Krenk *et al*[31]	20	70.5 (61-89)	26.4 (19-34)	7/13	Undisclosed
Lachiewicz *et al*[32]	188	71 (41-89)	30.9	49/139	Undisclosed
Meding *et al*[33]	128	63.8 ± 8.9	-	35/93	Undisclosed
Tsonga *et al*[34]	52	72.6 ± 5.9	29.79 ± 5.27	-	Undisclosed
Vaidya *et al*[35]	100	-	-	48/62	55 with diabetes, 65 with hypertension
Vissers *et al*[37]	44	63.5 (42.0-78.0)	30.8 (24.2-44.9)	20/24	Undisclosed
Vissers *et al*[36]	21	63.8 ± 9.4[1]	29.7 ± 5.0[1]	9/12	Undisclosed
Walker *et al*[40]	19	M: 69.1 ± 5, F: 69.0 ± 7.8	-	10/9	Undisclosed

[1]Includes total hip arthroplasty patients.

of adult populations[52]. The PASIPD, for example is somewhat similar to the PASE, but asks a slightly greater volume of questions, yet remains only moderately weakly related to accelerometry-based measures indicating potential validity issues[53]. The validity of the HLAQ may also be an issue with relatively weak relation to activity logs[54]. These concerns are further bolstered by a recent systematic review performed by van Poppel *et al*[55] that found generally poor evidence of adequate validity and reliability in physical activity questionnaires. More extensive validation was deemed to be required even for those that did demonstrate some initial degrees of reliability and validity.

To our knowledge, studies examining the potential impact that an intervention (TKA, in this case) might have on patients' perceptions of their physical activity levels have not been performed. We believe, however, a reasonable argument can be made that decreased pain in combination with enhanced functional performance may lead patients to perceive that they have become more active after TKA. Such an altered perception could explain the apparently dichotomous findings of the majority of self-reported measure compared to several accelerometry-based measures of physical activity. In fact, the only study to compare physical activity values collected prior to and after TKA using both self-report and accelerometry-based measures arrived at divergent results[26]. While patients reported increased levels of physical activity with self-report outcome measures, accelerometry reflected no alterations upon comparison of pre- to post-surgical values.

While self-reported outcome measures are compelling from the perspectives of cost efficiency and ease of administration, they may lack the accuracy required to assess physical activity in an orthopaedic population undergoing a significant intervention such as TKA, and the rehabilitation process typically associated with the surgery[52,53,55]. We suggest that accelerometry-based assessment of physical activity offers greater accuracy than self-reported measures due to validity compared to VO_2max, no significant difference in energy expenditure estimation as assessed by doubly labeled water, and the reliability required to assess the outcomes associated with TKA[56,57].

Time to follow-up

Another key difference in the identified studies is time from surgery to follow-up assessment. Time periods ranged from as few as three days to as many as 27 years[31,33]. This may preclude meaningful comparison of studies with different follow-up time points. We suspect that this may be the case as other factors (*e.g.*, functional performance and pain) vary greatly over time[22,58]. Differences/alterations in physical activity between any of these time points may also be altered by both acute chronic health issues as well as the normal course of aging.

Participant characteristics

Participant characteristics (Table 3) of the investigations discussed herein were highly variable. Although mean BMI was similar across studies, all but one study described a predominantly female population[38]. Furthermore, average participant age ranged from 61.1 to

74.8 years[28,41]. This difference may have impacted the ability to compare studies, as age is known to be negatively related to physical activity. This issue is further complicated as the influence of age in combination with an intervention (*e.g.*, TKA) on physical activity is unknown. Another potentially complicating factor is variation in patient comorbidities between studies. Of the articles discussed in this review, only three disclosed patient comorbidities. Of 169 total patients, In *et al*[38] contained 64 with metabolic syndrome, 40 with hypertension, 36 with diabetes, 13 with hypertension and diabetes. Of 90 total patients, Jones *et al*[29], contained patients with a Comorbidity Index of the American Academy of Orthopedic Surgeons Outcomes Data Collection Questionnaires = 0.9 ± 1.2. Of 100 total patients, Vaidya *et al*[35] contained 55 with diabetes, 65 with hypertension. BMI, age, and number/severity of comorbidities are patient characteristics that may have influenced the physical activity of the patients described by these studies.

FUTURE DIRECTIONS

Physical activity is critically important to both short- and long-term health in the population at large, but is of particular importance for patients undergoing TKA to maintain overall health and improve functional performance deficits commonly related to OA. To this end, we propose that further study of the relationship between TKA and physical activity needs to be performed using accelerometry-based outcome measures at multiple post-surgical time points. Potential predictors of physical activity performance after TKA, such as demographic and lifestyle characteristics, should also be investigated. Furthermore, to our knowledge intervention studies aimed to increase physical activity in patients after TKA have not been performed.

CONCLUSION

The investigation of physical activity following TKA is important for the understanding of overall health maintenance and identifying potential targets for improving physiological and functional outcomes. Physical activity (particularly walking) is an attractive intervention as it can be self-managed and performed on a daily basis with low cost and minimal equipment. Several recent investigations have examined physical activity following TKA, using a variety of outcome measures and time-points. On the one hand, some studies indicate that patients perceive themselves to be more physically active after TKA than they were before surgery. On the other hand, several studies using accelerometry-based outcomes indicate that physical activity for patients after TKA remains at or below pre-surgical levels. In addition, daily physical activity for patients following TKA may fall short of healthy age-matched controls and does not meet recommended daily amounts for health maintenance and/or improvement. More rigorous studies need to be performed investigating the effect of TKA on physical activity. Furthermore, future research should seek to create and refine interventions aimed to increase the amount of physical activity engaged in by patients having undergone TKA.

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