Physical activity interventions after hip or knee joint replacement: A systematic review

Timothy Ishaku[1] MSc, Shi-Mah Min[2] MSc, Michelle Hall[3] PhD

Author Affiliations

[1]School of Nursing, Midwifery and Health, Coventry University, Coventry, UK

Email address: ad2482@coventry.ac.uk

[2]Department of Physiotherapy, Sengkang General Hospital, Tampines, Singapore

Email address: mah.shi.min@skh.com.sg

[3]Division of Physiotherapy Education, School of Health Sciences, University of Nottingham, Nottingham, UK

Email address: michellehall@nottingham.ac.uk

Correspondence to

Timothy Ishaku: ad2482@coventry.ac.uk

Abstract

Purpose of review This study aims to describe and evaluate physical activity interventions in individuals that have undergone hip or knee joint replacement due to osteoarthritis.

Recent findings 11873 studies were screened. Seven studies with 627 participants, aged 50 to 85 years met the review criteria. Five randomised control trial, one longitudinal quasi-experimental study with a control group and one pre/post-test study with control group. Interventions included health coaching, a walking programme, a behavioural change intervention and an alpine skiing intervention delivered between 6 and 24 weeks.

Two studies reported change in physical activity using patient activity diaries and five used objective accelerometer data. All studies showed an increase in time spent being physically active in the intervention groups. One study also reported an increase in vitality.

Summary Few studies have investigated physical activity interventions after hip or knee joint replacement, and evidence for the effectiveness of physical activity interventions post-replacement is low. High quality studies are needed in this area to explore the potential benefits presented within this review.

Keywords: physical activity, exercise, hip replacement, knee replacement, systematic review.

Introduction

Joint replacement is a surgical intervention reserved for the treatment of end-stage osteoarthritis (OA) after other non-surgical interventions have failed [1, 2]. Annually, about 160,000 total hip and knee joint replacements are carried out in England and Wales alone [3]. Projection estimates from the United Kingdom clinical research datalink revealed that by the year 2035, a staggering number of 439,097 and 1,219,362 total hip replacements and total knee replacements will be carried out respectively [4]. Following joint replacement procedures, most patients report having improved quality of life (QOL) due to reduced pain and improved mobility [5-7]. Additionally, there is the expectation of an increase in patients' post-replacement physical activity levels [8].

Some reports have indicated that most patients are not sufficiently physically active following hip or knee replacement surgery [8, 9]. Recent objective accelerometer data from the Osteoarthritis Initiative showed that only 5% of OA patients who have undergone knee joint replacement were reported to meet the physical activity guidelines of 150 minutes of moderate-intensity physical activity [10]. A critical review by Paxton reported that ten studies found an increase in patients' physical activity levels (between 6 months to 5 years after joint replacement) compared to the pre-operative levels of physical activity. Five additional studies reported no change or even decreased physical activity levels (between 2 weeks to 6 months post-operation) [9]. These contradictory findings are likely due to the measurement tools used; patient-reported measures frequently describe higher levels of physical activity, which are inconsistent with objective measures such as accelerometer data. Several barriers to physical activity in this group have been reported, including a lack of patient education, fear of jeopardising recovery process, co-morbidities and a lack of specific physical activity interventions [11].

Physical activity confers a number of skeletal and neuromuscular health benefits to patients post joint replacement in terms of function and mobility [12, 13]. More importantly, however, is the effect on co-morbidities such as cardiovascular disease, obesity and diabetes, where physical activity is important for prevention and management [13]. Failure to increase physical activity in patients post-replacement may not modify the risk for increased mortality in this group [14].

Although complex, physical activity is a modifiable behaviour as shown by a number of systematic reviews in a range of patient and non-patient populations. [15]. A systematic review conducted by Müller and Khoo reported that non-face-to-face physical activity interventions--which include investigators phoning participants; the use of printed materials; and the use of media such as newspapers, TV, radio and website--were successful in increasing the physical activity levels of older adults [16]. Among patients with lower-limb OA, Williamson and colleagues showed that providing supervised exercise programs, educating patients about physical activity, and training them on how to develop self-management strategies resulted in a small but positive effect in increasing participants' physical activity [17]. However, to date, no review has evaluated physical activity interventions among patients who have undergone lower limb joint replacement.

The aims of this review are:

- To describe the physical activity interventions that have been trialled in individuals post hip or knee joint replacement

- To evaluate the effectiveness of physical activity interventions aimed at increasing physical activity in individuals who have undergone hip or knee joint replacement

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was used for this review (and a PRISMA checklist [18] at Appendix 1). The protocol of this review has been prospectively registered with PROSPERO (International prospective register of systematic reviews) with the registration number CRD42016033498 (http://www.crd.york.ac.uk/PROSPERO/)

Search strategy

The following electronic databases were searched from their respective date of inception to the second week of February 2020: CINAHL (EBSCO), EMBASE, MEDLINE (OVID), PsycINFO (Ovid), SCOPUS (Elsevier), SPORT Discus (EBSCO) and Web of Science (search strategies for all the databases are contained in Appendix 2). The search strategy for the MEDLINE database was first developed after consultation with an experienced librarian and adapted for other databases with modification. Additionally, the reference lists of the included studies were screened for possible relevant articles.

The following search terms were used: physical activity, exercise, hip replacement, knee replacement, pedometer, accelerometer, step count and behavioural change theory.

Eligibility criteria

Studies

Health interventions are evaluated using different approaches and designs [19], and it is recognised that this will be the first review of physical activity interventions after joint replacement. Therefore, this review considered experimental and observational study designs. Furthermore, both published and unpublished studies were considered if the full text was made available by the authors.

Participants

Participants included persons aged 18 years and above that have undergone hip or knee joint replacement due to OA. Participants needed to have undergone the replacement for the first time, which might have involved one or both limbs.

Interventions

The review considered any "systematic approach to increase physical activity" as a physical activity intervention [20].

The approach could have been a physical activity program alone or a particular physical activity component as part of a wider program, which could have been facility-based, home-based or both, undertaken in diverse ways and situations [19, 21].

The interventions could have been compared with a comparison group or not. Examples of these interventions include supervised exercise programs, unsupervised exercise programs, or behavioural change approaches aimed at increasing physical activity.

Outcome measures

Studies must have included either objective or self-reported measures of physical activity. Objective measures could include pedometers or accelerometers. Self-reported measures could include physical activity diary (PAD) or questionnaires such as International Physical Activity Questionnaire (I-PAQ).

Study selection

Studies identified were downloaded to EndNote Web (Thomas Reuters), where the duplicates were removed. One reviewer screened the titles and abstracts of the identified studies based on the study eligibility criteria identified above before retrieving the full text, and further screening was carried out by the same reviewer. A second reviewer screened the identified studies before inclusion into the review. Disagreements were resolved by a third reviewer.

Data extraction

A data extraction sheet (Appendix 3) from the Cochrane public health group was adapted. [(22)]

Two reviewers independently extracted the data from the included studies. Disagreements were resolved by consensus or, if needed, a third reviewer. The following data were extracted for this review: patient characteristics (age, gender, body mass index, duration post-replacement), type of joint affected (knee or hip), study design, sample size, description of interventions, description of control or comparator interventions, country and study results.

Methodological assessment of individual studies

The Joanna Briggs Institute (JBI) critical appraisal tool for experimental studies was used for assessing the quality of studies included. The appraisal tool was developed for both randomised and quasi-randomised studies. The tool consists of 10 questions, which are presented in table 1.

Two reviewers independently assessed the quality of the included studies. Disagreements were resolved by consensus and, where a consensus could not be reached, a third reviewer decided. The studies were graded as either having ‘Yes’, ‘No’ or ‘Unclear’ on each of the domains [23]. Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach (see table 2) was used to summarise the overall risk of bias assessment and other quality makers for the studies included [24].

Synthesis of results

There was considerable heterogeneity in the study designs, interventions and outcome measures which precluded a meta-analysis being performed. Therefore, narrative syntheses of the included studies were presented.

Based on the data presented in the original articles, we compared percentage or mean and standard deviation (SD) values in the intervention group with that of the control group. Further evaluations were carried out with the pre- and post-intervention values in both groups.

Results

Study selection

In total, 11873 studies were identified after searching the databases. 6186 duplicates were removed, and 5687 records were screened based on titles and abstracts. Full texts of 9 studies were retrieved where further screening was carried out. 7 studies finally met the inclusion criteria.

Based on title and abstract screening, 2 other potential studies--one of which was a conference abstract [25], the other a PhD dissertation [26]--were identified, efforts were made to retrieve full texts of both but were not successful.. Two other studies that are at the protocol stage were identified [27, 28] No relevant unpublished studies were obtained. See flow diagram in Figure 1.

Studies characteristics

Methods

Morishima et al. (2014), Paxton et al. (2018), Van der Walt et al. (2018), Hoorntje et al. (2020) and Losina et al. (2018) conducted randomised controlled trials (RCTs) which were delivered over 12, 12, 6, 24 and 24 week periods respectively [29-33]. Harnirattisai and Johnson (2005) used a longitudinal quasi-experimental study design with a control group to investigate the effectiveness of a behavioural change intervention. The intervention lasted for 6 weeks [34]. Würth et al (2015) investigated alpine skiing using pre-test, post-test with a control group design which was delivered over a period of 12 weeks [35]. All the studies were published in the English language.

Participants

The included studies had 627 participants in total with about 51% being male. The ages of all the participants in the included studies range from 50 to 85 years. The main inclusion criterion for these studies was having undergone hip or knee joint replacement for OA.

Intervention

There is variation in the physical activity interventions delivered within the included studies. The study conducted by Morishima et al., consisted of unsupervised walking at different intervals and levels of intensity. The intervention stipulated that the participants walk for 5 or more sets of low-level intensity (40% of VO_2max) followed by high level intensity (more than 70% but less than 85% VO_2peak). These targets were reviewed by physical therapists every two weeks and when the targets were not met, the therapists encouraged participants to increase their efforts [29]. The other four RCTs included in this study investigated the use of goal setting strategies with a feedback component among individuals that had undergone joint replacement [30-33]. Harnirattisai and Johnson's study was based on social cognitive theory, which includes nurse-patient interaction regarding the success and failure of physical activity and exercise. Goals for physical activity and exercise were set between 1 to 2 weeks and 3 to 6 weeks postoperatively, and patients were encouraged to engage in physical activity and exercise according to their capability. Additionally, family members were educated on the importance of (and their role in) engaging in physical activity and exercise. Information prompts about physical activity and exercise regime were also provided in week 1 to 2 (get started) and in week 3 to 6 (get stronger) postoperatively [34]. The study conducted by Würth et al investigated alpine skiing. The participants were divided into two groups, with one instructor per group [35].

Outcomes

All the randomised control trial studies used an objective physical activity measure which was an accelerometer-based activity monitor. PAD and the short version of I-PAQ [36], which are self-report measures, were used in the other three included studies. Participants' QOL was explicitly reported in 3 of the included studies in our review [31, 33, 35].

A tabulated description of the study characteristics is provided in Table 3.

Methodological quality assessment of individual studies

The risk of bias and other quality markers for the individual studies are shown in Table 4. In three or more of the quality domains, all the studies scored “NO” with the exception of Van der Walt et al. study which scored only two “NO”. Although it was reported as “NO”, it was recognised that it was not possible to blind participants to the treatment allocation. The possibility of attrition bias was higher in two studies [29, 35]. Data from the participants that withdrew from these studies were not included in the final analysis. The greatest methodological issue was the use of PAD to measure change in physical activity by the two studies included [34, 35]. An overall quality assessment based on the GRADE approach showed that the level of evidence is low, with most of the studies downgraded due to study design [24].

Synthesis of results

Table 5 shows the effects of the interventions on physical activity, QOL and any adverse events reported.

Self-reported physical activity

Würth et al. (2015) and Harnirattisai and Johnson (2005) reported a positive effect based on self-reported physical activity measures [34, 35]. Among the two studies, one study was based on a theoretical model (Bandura’s social cognitive theory), and it was aimed at improving participants’ self-efficacy. This was combined with an unsupervised exercise program. The study reported that a higher percentage (93%) of the participants in the intervention group walked 20 minutes daily, which is significantly greater than that of the control group (46%) [34]. In the other study, the participants undertook recreational alpine skiing. The greatest positive effect was recorded during the skiing days where the participants in the intervention group spent more time being active (mean±SD: 122.3±32.4 minutes per day) compared to the control (mean±SD: 75.1±21.3 minutes per day). However, during other days when participants are not skiing, the difference between the two groups was minimal (mean±SD: intervention -48.8±25.1 minutes per day; control -44.6±27.2 minutes per day) [35]. The intensity of contact and duration of intervention differs between the two studies.

Objective measures of physical activity

Morishima et al. (2014), implemented walking at a low intensity followed by high intensity. The study reported a non-significant effect in the overall total energy expenditure between the intervention and control group (Means±SE: Intervention-13824±1495 (O2 ml/kg/wk); control -10258±1827 (O2 ml/kg/wk); p≥0.05). However, there was a significant difference in the time spent in fast (high intensity) interval walking training between the two groups (Means±SE: Intervention is 127±18 minutes per week; control is 75±17. Van der Walt (2018) reported a significantly higher mean step count at all review points in the intervention group compared with the control group with a moderate size effect (Cohen's d 0.4-0.5). Losina et al. (2018), reported the weekly mean change of 39 (SD 11) minutes in the intervention arm compared to the control, and Paxton et al. (2018) reported that the intervention group recorded 20% increase (baseline: 5754 ± 2714, post-intervention: 6917 ± 3445) in daily step count following physical activity intervention, which was significantly higher compared to the control group (baseline: 5011 ± 2038, post-intervention: 5291 ± 2298).

Quality of life

One study used SF-36 to report participants' QOL [29]. The instrument has 8 domains [37]. The study reported a significant increase in only the vitality score of the intervention group (values changed from 45±3 to 52±2; p=0.005) but not in the control group (values change from 48±3 to 52±3; p=0.19) [29].

Adverse events

All the studies reported no adverse events related to the interventions [29-35].

Discussion

The evidence supporting the need for physical activity interventions after joint replacement is overwhelming [9, 11]. However, within the literature, few studies have investigated physical activity interventions after hip or knee joint replacement due to OA.

To the best of our knowledge, this is the first systematic review to evaluate the changes in physical activity and QOL following physical activity interventions among OA patients that have undergone hip or knee joint replacement. Of the 11873 studies screened, only 7 studies were included [29-35].

Summary of evidence

The present review provides low quality evidence (based on GRADE approach) for the effectiveness of physical activity interventions after hip or knee joint replacement due to OA.

Types of intervention

To increase participants' physical activity, all the studies implemented unsupervised, specified programs. Although, most of the included studies make use of different motivational strategies to enable participants to attain set goals (such as number of steps per day) as part of the intervention, only one study explicitly based its intervention on a well-researched behavioural change model [34]. This study used motivational strategies, which are based on social cognitive theory, to improve participants' self-efficacy. Mastery experience, verbal persuasion, family support and specifying the outcome expectations are components of the effective program that shaped participants' self-efficacy and outcome expectation, thereby bringing about the desired change.

Theoretical frameworks provide the basis for explaining how an intervention can influence a behaviour (such as physical activity) and the probable pathway for the change in the behaviour [38,39,40]. They can also inform the design, development and execution of physical activity interventions [40,41]. Therefore, interventions aimed at increasing physical activity after joint replacement should be guided by theoretical frameworks.

The interventions differ in frequency, intensity and duration, which might have been affected by the length of time since joint replacements. For instance, in one of the studies [34], the participants were recruited 4 days postoperatively, while in two other studies [29,35], the interventions were delivered to participants who had their joint replaced up to 15 years previously. Therefore, there is a lack of sufficient evidence to reliably state which delivery approach is more successful. The interventions were delivered for no more than 24 weeks with less contact between the participants and providers. For advancement into clinical practice, investigation should be conducted on the effectiveness of supervised versus unsupervised interventions as well as the cost and benefits associated with these interventions.

Physical activity measurement and methodology

There is lack of agreement on the research methodology particularly with regards to physical activity measurement. In two studies [34,35], an important shortcoming was the use of self-reported minutes of physical activity which might not capture the four domains of physical activity (domestic, transportation, leisure and occupation) [42,43]. The use of validated physical activity measures may provide detailed information across physical activity domains [42].

The use of objective physical activity measures, which could include wearing portable devices such as accelerometers, provide a possible way for individuals to self-monitor behavioural change and physical activity daily. An additional advantage that may be derived from integrating self-monitoring and wearable devices is an improvement in the evaluation of interventions that require less contact and in areas that are remote. Five of the included studies in the present review did make use of this methodology. However, these devices can be costly, requiring proper infrastructure for gathering and analysing the data [44].

The included studies in the current review did not follow up on the interventions delivered beyond 6 months. For precise quantification of health outcomes and cost-effectiveness, previous epidemiological modelling studies recommend that evaluation of outcome should persist beyond five years [45]. However, study attrition and limited funding make it challenging in practice for outcomes to be measured over a prolonged follow-up.

There is need for a consensus in the measurement of physical activity interventions after joint replacement and length of follow-up.

Effectiveness of physical activity interventions post-replacement

The present review identified a significant increase based on self-reported measure (PAD) in participants' physical activity. Among the two studies that used this measure, Harnirattisai and Johnson (2005) reported that a significant percentage of the participants in the intervention group (93%) were physically active, and this number is higher when compared with the control participants (46%) [34]. In the other study, the greatest positive effect was recorded during the skiing days on which the participants in the intervention group spent more time active (mean±SD: 122.3±32.4 minutes per day) when compared to the control (mean±SD: 75.1±21.3 minutes per day). However, during other days, when participants were not skiing, the difference between the two groups was minimal (mean±SD: intervention is 48.8±25.1 minutes per day; control is 44.6±27.2 minutes per day) [35]. Müller and Khoo (2014) reported a significant physical activity increase, based on self-reported measures of respective physical activity interventions, for older adults included within their review. This is comparable to our findings.

Small to moderate significant change in physical activity levels were reported in all studies that objectively assessed physical activity interventions following joint replacement [29-33]. These studies used accelerometer-based activity monitors to quantify participants' physical activity. For example, following an unsupervised, tailored exercise program, a non-significant difference in total energy expenditure could be seen between the intervention (means±SE: 13824±1495-O2 ml/kg/wk) and control group (means±SE: 10258±1827 -O2 ml/kg/wk). However, the time spent in fast walking by the intervention group (22 minutes per week) was significantly different from that of the control group (10 minutes per week) [29]. Two previous studies using a similar training program reported that adults without any joint replacement spent 22 to 27 minutes of fast walking time per day [46, 47]. Among sedentary individuals, 16 minutes per day of fast interval walking training has been reported to confer cardiovascular benefits [48]. Another included study within our review reported weekly mean change of 39 (SD 11) minutes [33].

Quality of life

Physical activity interventions have been reported to improve the QOL of sedentary older adults [49]. Within the present review, three studies measured participants' QOL using SF-36 [29] and EuroQol-5D [31, 33]. One study reported a significant increase in the vitality score of the intervention group [29]. Future physical activity intervention studies among OA patients post-replacement should consider including QOL measures to explore such improvements.

Adverse events

All the studies included in our review recorded no adverse events. Most experts recommend avoidance of high impact loading activities due to safety concerns. However, regardless of the potential consequences, patients do engage in such activities [50]. Therefore, rather than being dissuaded from engaging in such activities, patients should be individually assessed and made aware of the potential consequences [50]. This could help in promoting physically active lifestyles post-joint replacement.

Limitations of the included studies

The sample size of one of the included studies was small. Small sample size causes statistical analyses to be underpowered and can negatively affect the results of a study by obscuring the true effect [51]. This could make the findings of studies with low statistical power unreliable [51].

Most of the participants were recruited from a particular cultural [29, 34] or social group [35], which may affect the external validity of interventions investigated.

Changes to physical activity behaviour can be lost over a period of time [52] and none of the studies followed up on the interventions beyond 6 months. So, it is unclear whether the findings of those studies can be maintained over a long period of time.

Limitations of the review

Even though we hold the view that a thorough search was conducted, the present review includes only studies that are reported in English, and our search was limited to electronic databases. So, given the possible existence of other studies reported in different languages as well as those in the grey literature, the findings of the present review need to be interpreted with caution.

Furthermore, the results of this review may have a limited generalizability to the whole of OA-patients post-replacement in different clinical settings due to the small sample size.

Conclusion

Implication for practice

Painful lower-limb OA is associated with physical disability, which is a significant risk factor for CVD and increased mortality. The use of joint replacements for end–stage OA is largely successful for relieving pain and improving function. However, in terms of physical activity, there is evidence that patients do not increase their physical activity following total knee/hip replacement and do not meet the recommended physical activity guidelines for health. Therefore, promoting physical activity in this group is an important health goal.

Additionally, there is a lack of high-quality evidence relating to physical activity interventions among OA patients following hip or knee replacement. However, the low-quality evidence available suggests that physical activity interventions resulted in an increase in physical activity levels of OA patients, which in turn may potentially lead to health benefits. Moreover, these interventions may be safe among this population as there were no reported cases of adverse events.

Implication for research

The potential benefits presented within this review need further investigations. Most of the physical activity interventions were not based on behavioural change models. Interventions that are based on theoretical models have been reported to be more successful in influencing physical activity behaviour [15]. The included studies were of poor methodological quality. Moreover, most of the outcome measures used have poor reliability and are not validated among arthroplasty populations. Future studies--such as high quality, large-scale, randomised, controlled trials--should consider addressing these issues. We have also identified two randomised, controlled trials [27, 28] that are at the protocol stage which could add credence to the evidence regarding effective physical activity interventions.

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Conflict of interest

None declared

Author Contributions

Timothy Ishaku and Michelle Hall were involved in the conception and design of the study.

Timothy Ishaku, Shi-Mah Min and Michelle Hall were involved in the acquisition, analysis and interpretation of data. Also, all the authors were involved in the drafting of the article and the final approval of the version to be submitted.

References

Papers of particular interest, published recently, have been highlighted as:

▪ Of importance

1. Carr AJ, Robertsson O, Graves S, Price AJ, Arden NK, Judge A, et al. Knee replacement. The Lancet. 2012;379(9823):1331-40. doi:http://dx.doi.org/10.1016/S0140-6736(11)60752-6

2. Felson DT, Lawrence RC, Hochberg MC, McAlindon T, Dieppe PA, Minor MA, et al. Osteoarthritis: New Insights. Part 2: Treatment Approaches. Annals of Internal Medicine. 2000;133(9):726-37. doi:10.7326/0003-4819-133-9-200011070-00015

3. National Joint Registry. Joint replacement statistics [online] 2014. Available from: http://www.njrcentre.org.uk/njrcentre/Patients/Jointreplacementstatistics/tabid/99/Default.aspx. [Accessed 09 August, 2016.]

4. Culliford D, Maskell J, Judge A, Cooper C, Prieto-Alhambra D, Arden NK. and COASt Study Group. Future projections of total hip and knee arthroplasty in the UK: results from the UK Clinical Practice Research Datalink. Osteoarthritis and Cartilage. 2015; 23(4), 594-600.http://dx.doi.org/10.1016/j.joca.2014.12.022#

5. March LM, Cross MJ, Lapsley H, Brnabic AJM, Tribe KL, Bachmeier CJM, et al. Outcomes after hip or knee replacement surgery for osteoarthritis. A prospective cohort study comparing patients' quality of life before and after surgery with age-related population norms. Medical Journal of Australia. 1999;171(5):235-8.

6. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clinical Orthopaedics & Related Research. 2010;468(1):57-63. doi:10.1007/s11999-009-1119-9

7. Hamilton DF, Lane JV, Gaston P, Patton JT, MacDonald D, Simpson AHRW, et al. What determines patient satisfaction with surgery? A prospective cohort study of 4709 patients following total joint replacement. BMJ Open. 2013;3(4). doi:10.1136/bmjopen-2012-002525

8. Lützner C, Beyer F, Kirschner S, Lützner J. How Much Improvement in Patient Activity Can Be Expected After TKA? Orthopedics. 2016;39(3):S18-S23. doi: 10.3928/01477447-20160509-15.

9. ▪Paxton RJ, Melanson EL, Stevens-Lapsley JE, Christiansen CL. Physical activity after total knee arthroplasty: A critical review. World Journal of Orthopedics. 2015;6(8):614-22. doi:10.5312/wjo.v6.i8.614. **This review gives an overview into the whole issues with post-knee replacement including variability in the outcomes measures used to measure physical activity post-knee repalcement.**

10. ▪ Kahn TL, Schwarzkopf R. Does Total Knee Arthroplasty Affect Physical Activity Levels? Data from the Osteoarthritis Initiative. The Journal of Arthroplasty. 2015;30(9):1521-5. doi:http://dx.doi.org/10.1016/j.arth.2015.03.016. **This decribes the degree people are not meeting the physical activity guidleines post-joint replacment.**

11. Smith TO, Latham S, Maskrey V, Blyth A. Patients' perceptions of physical activity before and after joint replacement: a systematic review with meta-ethnographic analysis. Postgraduate Medical Journal. 2015;91(1079):483-91. doi:10.1136/postgradmedj-2015-133507

12. Kuster MS. Exercise recommendations after total joint replacement. Sports medicine. 2002;32(7), pp.433-445.

13. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. Canadian Medical Association Journal. 2006;174. doi:10.1503/cmaj.051351

14. Kluzek S, Sanchez-Santos MT, Leyland KM, Judge A, Spector TD, Hart D, et al. Painful knee but not hand osteoarthritis is an independent predictor of

mortality over 23 years follow-up of a population-based cohort of middle-aged women. Annals of the Rheumatic Diseases. 2015. doi:10.1136/annrheumdis-2015-208056

15. ▪Buchan DS, Ollis S, Thomas NE, Baker JS. Physical Activity Behaviour: An Overview of Current and Emergent Theoretical Practices. Journal of Obesity. 2012;2012:11. doi:10.1155/2012/546459. **This review summarises behavioural change models and highlited the need for physical activity interventions to be guided by these models.**

16. Müller AM, Khoo S. Non-face-to-face physical activity interventions in older adults: a systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2014;11(1):1-12. doi:10.1186/1479-5868-11-35

17. Williamson W, Kluzek S, Roberts N, Richards J, Arden N, Leeson P, et al. Behavioural physical activity interventions in participants with lower-limb osteoarthritis: a systematic review with meta-analysis. BMJ Open. 2015;5(8). doi:10.1136/bmjopen-2015-007642

18. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Annals of internal medicine. 2009;151(4):264-9. doi:10.7326/0003-4819-151-4-200908180-00135

19. Baker PRA, Francis DP, Soares J, Weightman AL, Foster C. Community wide interventions for increasing physical activity. The Cochrane database of systematic reviews. 2015. doi: 10.1002/14651858.CD008366.pub2.

20. World Health Organisation. Review of best practice in interventions to promote physical activity in developing countries. 2008. Switzerland: WHO Press.

21. Freak-Poli RL, Cumpston M, Peeters A, Clemes SA. Workplace pedometer interventions for increasing physical activity. The Cochrane database of systematic reviews. 2013. doi: 10.1002/14651858.CD009209.pub2.

22. Cochrane Public Health Group. Data extraction and assessment template 2011. The Cochrane library.

23. The Joanna Briggs Institute. Joanna Briggs Institute reviewers' manual. The Joanna Briggs Institute Adelaide; 2014.

24. Higgins JPT, Green S. Cochrane handbook for systematic reviews of interventions: Wiley Online Library; 2008.

25. Li Z, Jiang L, Lin J. The effect of education for daily physical activity level recovery of osteoarthritis patients after total knee arthroplasty. A prospective randomized controlled clinical trial using accelerometry. Osteoarthritis and Cartilage. 2015; 23:[A373 p.]. DOI: http://dx.doi.org/10.1016/j.joca.2015.02.686

26. Frost KL. Influence of a motivational exercise counseling intervention on rehabilitation outcomes in individuals with arthritis who received total hip replacement. Dissertation Abstracts International: Section B: The Sciences and Engineering. 2005;65(7-B):3424.

27. Kline, P.W., Melanson, E.L., Sullivan, W.J., Blatchford, P.J., Miller, M.J., Stevens-Lapsley, J.E. and Christiansen, C.L., 2019. Improving Physical Activity Through Adjunct Telerehabilitation Following Total Knee Arthroplasty: Randomized Controlled Trial Protocol. Physical therapy, 99(1), pp.37-45.

28. Christiansen, M.B., Thoma, L.M., Master, H., Schmitt, L.A., Pohlig, R. and White, D.K., 2018. A Physical Therapist–Administered Physical Activity Intervention After Total Knee Replacement: Protocol for a Randomized Controlled Trial. Physical therapy, 98(7), pp.578-584.

29. Morishima Y, Mizushima T, Yamauchi K, Morikawa M, Masuki S, Nose H. Effects of home-based interval walking training on thigh muscle strength and aerobic capacity in female total hip arthroplasty patients: a randomized, controlled pilot study. PloS one. 2014;9(9). doi: 10.1371/journal.pone.0108690

30. Paxton, R.J., Forster, J.E., Miller, M.J., Gerron, K.L., Stevens-Lapsley, J.E. and Christiansen, C.L., 2018. A feasibility study for improved physical activity after total knee arthroplasty. Journal of aging and physical activity, 26(1), pp.7-13.

31. Van der Walt, N., Salmon, L.J., Gooden, B., Lyons, M.C., O'Sullivan, M., Martina, K., Pinczewski, L.A. and Roe, J.P., 2018. Feedback from activity trackers improves daily step count after knee and hip arthroplasty: a randomized controlled trial. The Journal of arthroplasty, 33(11), pp.3422-3428.

32. ▪Hoorntje, A., Witjes, S., Kuijer, P.P.F., Bussmann, J.B., Horemans, H.L., Kerkhoffs, G.M., van Geenen, R.C. and Koenraadt, K.L., 2020. Does Activity-Based Rehabilitation With Goal Attainment Scaling Increase Physical Activity Among Younger Knee Arthroplasty Patients? Results From the Randomized Controlled ACTION Trial. The Journal of arthroplasty, 35(3), pp.706-711. **A**

study that objectively quantify physical activity post-repalcement following physical activity intervention.

33. Losina, E., Collins, J.E., Deshpande, B.R., Smith, S.R., Michl, G.L., Usiskin, I.M., Klara, K.M., Winter, A.R., Yang, H.Y., Selzer, F. and Katz, J.N., 2018. Financial incentives and health coaching to improve physical activity following total knee replacement: a randomized controlled trial. Arthritis care & research, 70(5), pp.732-740.

34. Harnirattisai T, Johnson RA. Effectiveness of a behavioural change intervention in Thai elders after knee replacement. Nursing Research. 2005;54(2):97-107.

35. Würth S, Finkenzeller T, Pötzelsberger B, Müller E, Amesberger G. Alpine Skiing With total knee ArthroPlasty (ASWAP): physical activity, knee function, pain, exertion, and well-being. Scandinavian journal of medicine & science in sports. 2015;25(S2):74-81. DOI: 10.1111/sms.12489

36. Lee, P.H., Macfarlane, D.J., Lam, T.H. and Stewart, S.M., 2011. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. International Journal of Behavioral Nutrition and Physical Activity, 8(1), p.115.

37. Ware Jr JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. Medical Care. 1992:473-83.

38. Allender S, Cowburn G, FOSTER C. Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. Health Education Research, 2006;21(6), 826-835.

39. Cavill N, Roberts K, Rutter H. Standard evaluation framework for physical activity interventions. National Obesity Observervatory. 2012.

40. Quinn L, Trubey R, Gobat N, Dawes H, Edwards RT, Jones C, Townson J, Drew C, Kelson M, Poile V, Rosser A, Hood K, Busse M. Development and delivery of a physical activity intervention for people with huntington disease: facilitating translation to clinical practice. Journal of Neurology Physical Therapy, 2016;40(2), 71-80.

41. Richards J, Hillsdon M, Thorogood M, Foster C. Face-to-face interventions for promoting physical activity. The Cochrane database of systematic reviews. 2013;Article No. Cd010392. Chichester, U.K: John Wiley and Sons, Ltd.

42. Strath SJ, Kaminsky LA, Ainsworth BE, Ekelund U, Freedson PS, Gary RA, et al. Guide to the Assessment of Physical Activity: Clinical and Research Applications. Circulation. 2013;128(20):2259-79.

43. Ainsworth BE, Caspersen CJ, Matthews CE, Mâsse LC, Baranowski T, Zhu W. Recommendations to Improve the Accuracy of Estimates of Physical Activity Derived from Self Report. Journal of physical activity & health. 2012;9(0 1):S76-S84.

44. Troiano RP, McClain JJ, Brychta RJ, Chen KY. Evolution of accelerometer methods for physical activity research. British Journal of Sports Medicine. 2014;48(13):1019-23. doi: 10.1136/bjsports-2014-093546

45. Jarrett J, Woodcock J, Griffiths UK, Chalabi Z, Edwards P, Roberts I, et al. Effect of increasing active travel in urban England and Wales on costs to the National Health Service.The Lancet. 2012;379(9832):2198-205. doi:10.1016/s0140-6736(12)60766-1

46. Morikawa M, Okazaki K, Masuki S, Kamijo Y, Yamazaki T, Gen-no H, et al. Physical fitness and indices of lifestyle-related diseases before and after interval walking training in middle-aged and older males and females. British Journal of Sports Medicine. 2011;45(3):216-24.

47. Okazaki K, Yazawa D, Goto M, Kamijo YI, Furihata M, Gen-no H, et al. Effects of macronutrient intake on thigh muscle mass during home-based walking training in middle-aged and older women. Scandinavian Journal of Medicine and Science in Sports. 2013;23(5):286-92. doi:10.1111/sms.12076

48. Lalande S, Okazaki K, Yamazaki T, Nose H, Joyner MJ, Johnson BD. Effects of interval walking on physical fitness in middle-aged individuals. Journal of Primary Care and Community Health. 2010;1(2):104-10. doi:10.1177/2150131910363598

49. Broekhuizen K, de Gelder J, Wijsman AC, Wijsman WL, Westendorp GJR, Verhagen E, et al. An Internet-Based Physical Activity Intervention to Improve Quality of Life of Inactive Older Adults: A Randomized Controlled Trial. Journal of Medical Internet Research. 2016;18(4):74. doi:10.2196/jmir.4335

50. Bauman S, Williams D, Petruccelli D, Elliott W, de Beer J. Physical activity after total joint replacement: a cross-sectional survey. Clinical Journal of Sport Medicine. 2007;17(2):104-8. doi:10.1097/JSM.0b013e3180379b6a

51. Button KS, Ioannidis JPA, Mokrysz C, Nosek BA, Flint J, Robinson ESJ, et al. Power failure: why small sample size undermines the reliability of neuroscience. Nature Reviews Neuroscience. 2013;14(5):365-76. doi:10.1038/nrn3475

52. Marcus BH, Dubbert PM, Forsyth LH, McKenzie TL, Stone EJ, Dunn AL, et al. Physical activity behavior change: issues in adoption and maintenance. Health Psychol. 2000;19(1 Suppl):32-41.