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

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19 **Abstract**

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

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

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

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

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

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52 **Introduction**

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54 Joint replacement is a surgical intervention reserved for the treatment of end-stage
55 osteoarthritis (OA) after other non-surgical interventions have failed ^(1, 2). Annually,
56 about 160,000 total hip and knee joint replacements are carried out in England and
57 Wales alone ⁽³⁾. Projection estimates from the United Kingdom clinical research
58 datalink revealed that by the year 2035, a staggering number of 439,097 and
59 1,219,362 total hip replacements and total knee replacements will be carried out
60 respectively ⁽⁴⁾. Following joint replacement procedures, most patients report having
61 improved quality of life (QOL) due to reduced pain and improved mobility ⁽⁵⁻⁷⁾.
62 Additionally, there is the expectation of an increase in patients' post-replacement
63 physical activity levels ⁽⁸⁾.

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

77 fear of jeopardising recovery process, co-morbidities and a lack of specific physical
78 activity interventions ⁽¹¹⁾.

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

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

97 The aims of this review are:

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

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

103 **Methods**

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

110 Search strategy

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

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

122 Eligibility criteria

123 Studies

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

129 Participants

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

133 Interventions

134 The review considered any “systematic approach to increase physical activity” as a
135 physical activity intervention ⁽²⁰⁾.

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

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

143 Outcome measures

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

148 Study selection

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

155 Data extraction

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

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

164 Methodological assessment of individual studies

165 The Joanna Briggs Institute (JBI) critical appraisal tool for experimental studies was
166 used for assessing the quality of studies included. The appraisal tool was developed

167 for both randomised and quasi-randomised studies. The tool consists of 10 questions,
168 which are presented in table 1.

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

176 Synthesis of results

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

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

184 **Results**

185

186 Study selection

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

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

196 Studies characteristics

197 Methods

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

206 Participants

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

211 Intervention

212 There is variation in the physical activity interventions delivered within the included
213 studies. The study conducted by Morishima et al., consisted of unsupervised walking
214 at different intervals and levels of intensity. The intervention stipulated that the

215 participants walk for 5 or more sets of low-level intensity (40% of VO₂max) followed by
216 high level intensity (more than 70% but less than 85% VO₂peak). These targets were
217 reviewed by physical therapists every two weeks and when the targets were not met,
218 the therapists encouraged participants to increase their efforts ⁽²⁹⁾. The other four
219 RCTs included in this study investigated the use of goal setting strategies with a
220 feedback component among individuals that had undergone joint replacement ⁽³⁰⁻³³⁾.
221 Harnirattisai and Johnson's study was based on social cognitive theory, which includes
222 nurse-patient interaction regarding the success and failure of physical activity and
223 exercise. Goals for physical activity and exercise were set between 1 to 2 weeks and
224 3 to 6 weeks postoperatively, and patients were encouraged to engage in physical
225 activity and exercise according to their capability. Additionally, family members were
226 educated on the importance of (and their role in) engaging in physical activity and
227 exercise. Information prompts about physical activity and exercise regime were also
228 provided in week 1 to 2 (get started) and in week 3 to 6 (get stronger) postoperatively
229 ⁽³⁴⁾. The study conducted by Würth et al investigated alpine skiing. The participants
230 were divided into two groups, with one instructor per group ⁽³⁵⁾.

231 Outcomes

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

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

238 Methodological quality assessment of individual studies

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

249 Synthesis of results

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

252 Self-reported physical activity

253 Würth et al. (2015) and Harnirattisai and Johnson (2005) reported a positive effect
254 based on self-reported physical activity measures ^(34, 35). Among the two studies, one
255 study was based on a theoretical model (Bandura’s social cognitive theory), and it was
256 aimed at improving participants’ self-efficacy. This was combined with an
257 unsupervised exercise program. The study reported that a higher percentage (93%)
258 of the participants in the intervention group walked 20 minutes daily, which is
259 significantly greater than that of the control group (46%) ⁽³⁴⁾. In the other study, the
260 participants undertook recreational alpine skiing. The greatest positive effect was
261 recorded during the skiing days where the participants in the intervention group spent

262 more time being active (mean±SD: 122.3±32.4 minutes per day) compared to the
263 control (mean±SD: 75.1±21.3 minutes per day). However, during other days when
264 participants are not skiing, the difference between the two groups was minimal
265 (mean±SD: intervention -48.8±25.1 minutes per day; control -44.6±27.2 minutes per
266 day) ⁽³⁵⁾. The intensity of contact and duration of intervention differs between the two
267 studies.

268 Objective measures of physical activity

269 Morishima et al. (2014), implemented walking at a low intensity followed by high
270 intensity. The study reported a non-significant effect in the overall total energy
271 expenditure between the intervention and control group (Means±SE: Intervention-
272 13824±1495 (O₂ ml/kg/wk); control -10258±1827 (O₂ ml/kg/wk); p≥0.05). However,
273 there was a significant difference in the time spent in fast (high intensity) interval
274 walking training between the two groups (Means±SE: Intervention is 127±18 minutes
275 per week; control is 75±17. Van der Walt (2018) reported a significantly higher mean
276 step count at all review points in the intervention group compared with the control
277 group with a moderate size effect (Cohen's d 0.4-0.5). Losina et al. (2018), reported
278 the weekly mean change of 39 (SD 11) minutes in the intervention arm compared to
279 the control, and Paxton et al. (2018) reported that the intervention group recorded 20%
280 increase (baseline: 5754 ± 2714, post-intervention: 6917 ± 3445) in daily step count
281 following physical activity intervention, which was significantly higher compared to the
282 control group (baseline: 5011 ± 2038, post-intervention: 5291 ± 2298).

283 Quality of life

284 One study used SF-36 to report participants' QOL ⁽²⁹⁾. The instrument has 8 domains
285 ⁽³⁷⁾. The study reported a significant increase in only the vitality score of the

286 intervention group (values changed from 45±3 to 52±2; p=0.005) but not in the control
287 group (values change from 48±3 to 52±3; p=0.19) ⁽²⁹⁾.

288 Adverse events

289 All the studies reported no adverse events related to the interventions ⁽²⁹⁻³⁵⁾.

290 **Discussion**

291

292 The evidence supporting the need for physical activity interventions after joint
293 replacement is overwhelming ^(9, 11). However, within the literature, few studies have
294 investigated physical activity interventions after hip or knee joint replacement due to
295 OA.

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

300 Summary of evidence

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

304 Types of intervention

305 To increase participants' physical activity, all the studies implemented unsupervised,
306 specified programs. Although, most of the included studies make use of different
307 motivational strategies to enable participants to attain set goals (such as number of
308 steps per day) as part of the intervention, only one study explicitly based its
309 intervention on a well-researched behavioural change model ⁽³⁴⁾. This study used

310 motivational strategies, which are based on social cognitive theory, to improve
311 participants' self-efficacy. Mastery experience, verbal persuasion, family support and
312 specifying the outcome expectations are components of the effective program that
313 shaped participants' self-efficacy and outcome expectation, thereby bringing about the
314 desired change.

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

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

331 Physical activity measurement and methodology

332 There is lack of agreement on the research methodology particularly with regards to
333 physical activity measurement. In two studies ^(34,35), an important shortcoming was the

334 use of self-reported minutes of physical activity which might not capture the four
335 domains of physical activity (domestic, transportation, leisure and occupation) ^(42,43).

336 The use of validated physical activity measures may provide detailed information
337 across physical activity domains ⁽⁴²⁾.

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

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

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

354 Effectiveness of physical activity interventions post-replacement

355 The present review identified a significant increase based on self-reported measure
356 (PAD) in participants' physical activity. Among the two studies that used this measure,
357 Harnirattisai and Johnson (2005) reported that a significant percentage of the

358 participants in the intervention group (93%) were physically active, and this number is
359 higher when compared with the control participants (46%)⁽³⁴⁾. In the other study, the
360 greatest positive effect was recorded during the skiing days on which the participants
361 in the intervention group spent more time active (mean±SD: 122.3±32.4 minutes per
362 day) when compared to the control (mean±SD: 75.1±21.3 minutes per day). However,
363 during other days, when participants were not skiing, the difference between the two
364 groups was minimal (mean±SD: intervention is 48.8±25.1 minutes per day; control is
365 44.6±27.2 minutes per day)⁽³⁵⁾. Müller and Khoo (2014) reported a significant physical
366 activity increase, based on self-reported measures of respective physical activity
367 interventions, for older adults included within their review. This is comparable to our
368 findings.

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

383 Quality of life

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

390 Adverse events

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

398 Limitations of the included studies

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

403 Most of the participants were recruited from a particular cultural ^(29, 34) or social group
404 ⁽³⁵⁾, which may affect the external validity of interventions investigated.

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

408 Limitations of the review

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

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

417 **Conclusion**

418

419 Implication for practice

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

427 Additionally, there is a lack of high-quality evidence relating to physical activity
428 interventions among OA patients following hip or knee replacement. However, the low-

429 quality evidence available suggests that physical activity interventions resulted in an
430 increase in physical activity levels of OA patients, which in turn may potentially lead to
431 health benefits. Moreover, these interventions may be safe among this population as
432 there were no reported cases of adverse events.

433 Implication for research

434 The potential benefits presented within this review need further investigations. Most of
435 the physical activity interventions were not based on behavioural change models.
436 Interventions that are based on theoretical models have been reported to be more
437 successful in influencing physical activity behaviour ⁽¹⁵⁾. The included studies were of
438 poor methodological quality. Moreover, most of the outcome measures used have
439 poor reliability and are not validated among arthroplasty populations. Future studies-
440 -such as high quality, large-scale, randomised, controlled trials--should consider
441 addressing these issues. We have also identified two randomised, controlled trials ^{(27,}
442 ²⁸⁾ that are at the protocol stage which could add credence to the evidence regarding
443 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](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 replacement.**
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 describes the degree people are not meeting the physical activity guidelines post-joint replacement.**
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 highlighted 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., Geron, 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-replacement 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.