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Is there a difference in physical activity levels in patients before and up to one year after unilateral total hip replacement? A systematic review and meta-analysis

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Abstract

Objective: To determine the difference in physical activity levels before and up to one year after unilateral primary total hip replacement.

Data sources: A search was performed on 13 July 2016. Studies were eligible for inclusion if they presented preoperative and up to one year postoperative measures of physical activity for patients who had undergone unilateral primary total hip replacement.

Review methods: Any article that used a measure of physical activity pre and up to one year post-unilateral primary total hip replacement. Data was synthesised using a meta-analysis with 95% confidence intervals (CI), if appropriate. The Critical Appraisal Skills Programme cohort study checklist was used to assess the quality of evidence.

Results: From 6024 citations, 17 studies were selected: Nine studies were analysed in a meta-analysis and eight studies were analysed qualitatively. The quality of the evidence was 'low' to 'moderate'. There was no statistically significant difference in physical activity pre- to post-total hip replacement when assessed using: movement-related activity (mean difference (MD): −0.08; 95% CI: 1.60, 1.44; $I^2 = 0\%$; n = 77), percentage of 24-hours spent walking (MD: −0.21; 95% CI: −1.36, 0.93; $I^2 = 12\%$; $n = 65$), 6-minute walk test (MD: −60.85; 95% CI: −122.41, 0.72; $I^2 = 84\%$; $n = 113$) or the cardiopulmonary exercise test (MD: −0.24; 95% CI: −1.36, 0.87; $I^2 = 0\%$; $n = 76$).

Conclusion: There is no statistically significant difference in physical activity levels before and up to one year after unilateral primary total hip replacement. However, the low to moderate methodological quality of the included articles should be taken into consideration when drawing conclusions.

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Introduction

Total hip replacement is one of the most common elective orthopaedic operations. A total of 620,300 total hip replacements were undertaken in England, Wales and Northern Ireland from April 2003 to December 2013[1]. Osteoarthritis is the most common indication, estimated to be the principle reason for 93% of total hip replacements.[1] Of these patients, 40% are male, with the median age at operation being 69 years.

Physical activity is a generic term encompassing any activity that involves movement that results in an increase in heart rate and calorific expenditure, the amount of calories burnt.[2] Physical activity can be subdivided into three categories: (1) everyday activity, e.g. active travel such as walking or cycling; (2) active recreation, e.g. gardening, home improvement or recreational walking; and (3) sport that may be competitive or non-competitive.[2]

Previous systematic reviews have focused on total hip replacement and exercise[3–5] or alternatively have combined total hip and knee replacements together.[6] No previous systematic reviews have investigated the relationship between total hip replacement and physical activity, and specifically whether physical activity changes after total hip replacement. This is an important void in the evidence-base, as physical inactivity has been associated with the development of numerous non-communicable diseases.[2] Given this, the purpose of this systematic review is to answer the question: Is there a difference in physical activity levels in patients before and up to one year after unilateral total hip replacement?

Methods

This study was undertaken in accordance with the Cochrane collaboration guidelines.[7] The electronic databases AMED, CINHAL, EMBASE, Medline, Central (Cochrane), OpenSigle, ClinicalTrials.gov and UK Clinical Trials Gateway were searched from their inception up and to the 13 July 2016. The reference lists of all potentially eligible articles identified from the search strategy were reviewed. An example of the search strategy is presented in Appendix 1, available online.

For articles to be included in this systematic review, all participants: Had to be over 18 years; had any form of elective unilateral primary total hip replacement; and physical activity data was collected before and within the first postoperative year. One year postoperatively was chosen as this study is examining immediate postoperative change opposed to long-term postoperative patterns in physical activity. Articles were excluded if participants had more than one surgical procedure in the same operation, for example unilateral total hip replacement and bunion removal. Participants with other health conditions were included. Reviews were not included in the systematic review, but the reference list was read and any articles that fit the inclusion criteria were included. Any study design was included in the study. No date restrictions were applied. Only articles written in English were included.

In accordance with Cochrane Collaboration guidelines,[7] initially article titles and abstracts were independently screened for eligibility by two reviewers (TW, SL). For those articles that were potentially eligible and those where eligibility was unclear, the full text was then obtained and reviewed independently by each reviewer (TW, SL). Articles that both reviewers agreed had met the eligibility criteria after reviewing the full text were included. Any uncertainties were resolved through discussion.

Outcomes

The primary outcome measure was change in physical activity within the initial 12 months post-total hip replacement. Physical activity was defined using the British Government's, Department of Health's definition being: 'all forms of activity such as everyday walking or cycling to get from "A to B", active play work-related activity, active recreation (such as working out in a gym), dancing, gardening or playing active games, as well as organised and competitive sport'.[2] All outcomes that measured physical activity were considered for this systematic review. This included, but is not limited to, accelerometer and physical activity questionnaires, for example physical activity score for the elderly[8] and global physical activity questionnaire.[9]

Secondary outcome measures for this study were considered to be any measure that measures physiological exercise capacity, this includes but is not limited to maximal and submaximal exercise tests. Measures of strength or power, such as strength dynamometry, were not considered measures of physical activity in this systematic review and therefore excluded. Similarly, biomechanical measures, such as walking speed and peak impact force, were not considered measures of physical activity, as these are measures of physiological and/or biomechanical efficiency.

Data extraction and critical appraisal

Data from all eligible articles were extracted using a data extraction table. The primary reviewer (TW) independently screened and extracted data from each eligible article. Following the independent screening and extraction from the primary reviewer, a second reviewer (SL) checked the screening and extraction for accuracy. Any disagreement in screening or data extraction were resolved through discussion. A third reviewer (TS) was not needed to adjudicate any disagreements, on this occasion there were no disagreements. Data extracted included: Number of participants, age, gender, indication for total hip replacement (e.g. osteoarthritis), physical activity measure and pre-/postoperative total hip replacement physical activity data. In the event of missing data, the corresponding authors were emailed and asked for further information.

All included studies were appraised using the Critical Appraisal Skills Programme Cohort Study Checklist.[10] This is a 12-item appraisal tool that has been previously used in rehabilitation research.[10] An additional question (6c. Was the characteristics of excluded participants examined?) was incorporated to the appraisal tool, as this was considered specifically important to this review to better ascertain generalisability and acceptability of physical activity to the population. All included articles were independently assessed using this tool by one reviewer (TW), and verified by a second (SL). Any disagreements in critical appraisal assessment were resolved through discussion, if needed a third reviewer (TS) was available to resolve any disagreements.

Data synthesis and analysis

Heterogeneity was initially assessed by examining the data extraction tables by three reviewers (TW, AC, TS). When clinical homogeneity was assumed a meta-analysis was deemed appropriate. If clinical heterogeneity was evident, a narrative review of the evidence was undertaken.

For each meta-analyses, statistical heterogeneity was assessed using I^2 and Chi^2 statistics. When I^2 was 20% or less and Chi^2 was less than $p=0.10$, a fixed-effects model was adopted.[7] When this was not satisfied, a random-effect model was used.[7] All meta-analyses were assessed as mean differences (MD) with 95% confidence interval (CI) and presented using forest plots. To determine whether age was a potentially important variable for outcome, a subgroup analysis was undertaken to assess the levels of physical activity pre- vs. postoperatively, specifically for people aged 65 years or over. Analyses were undertaken using Review Manager software (Review Manager (RevMan) [Computer Program] Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

Results

Search results

A summary of the search results is presented in Figure 1. A total of 6024 articles were identified

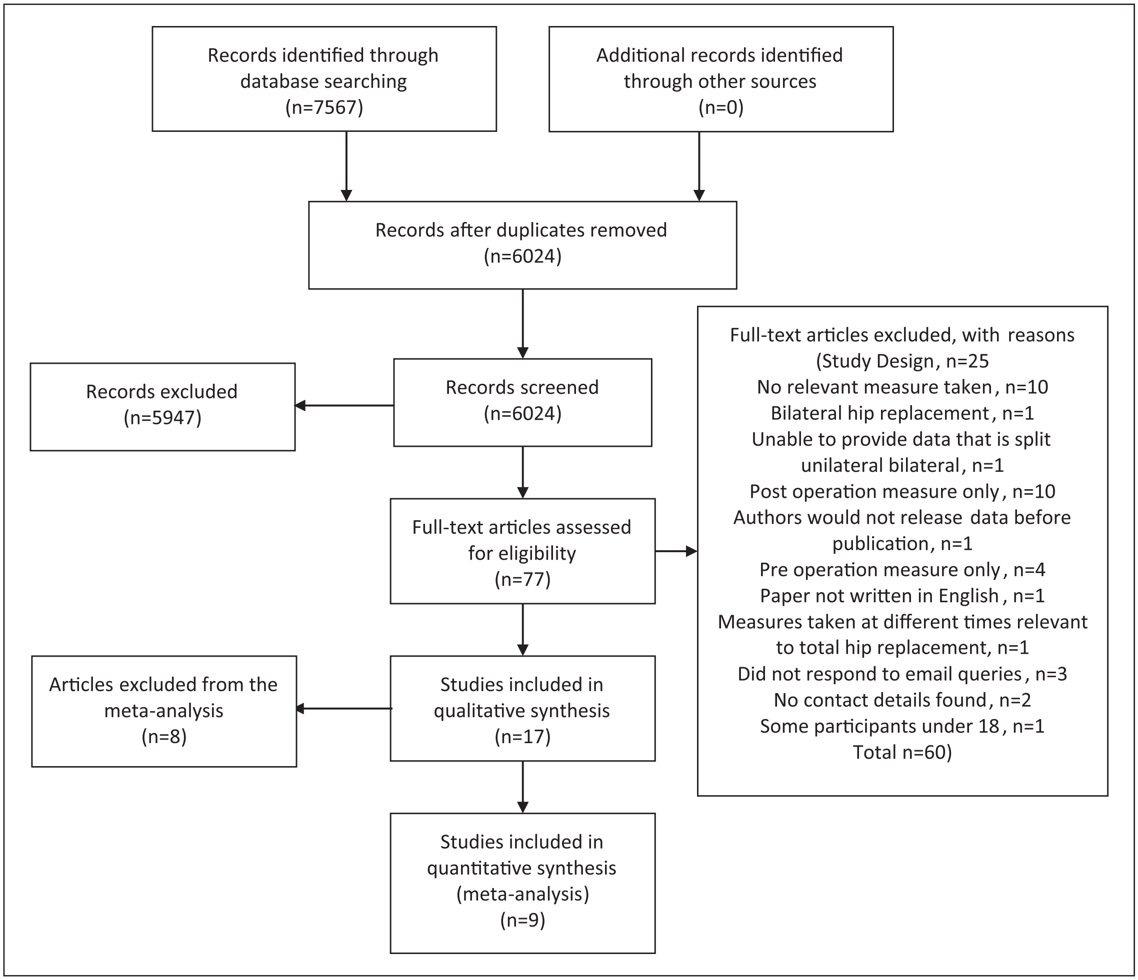

Figure 1. Flowchart of search results.

after duplicates were removed. Of these, 17 were eligible and included. Nine articles provided sufficient data that were used in the meta-analysis.[11–18] Eight articles[19–26] were not included in the meta-analysis as the data was either not appropriate to synthesise or not presented in an appropriate way for pooled analysis to take place.

A summary of the study appraisal results is presented in Table 1. Overall the evidence base was poor to moderate in quality. All studies clearly addressed a focused research question. All studies, with the exception of four, clearly explained the recruitment methods used.[15,16,21,26]

A summary of the demographic data for all included articles is presented in Table 2. In total, 1030 participants were included; Arbuthnot et al.[22] did not clearly state the number of participants in their study. Cohort sample sizes ranged from one[15] to 88 participants.[17] Three studies[15,22,24] did not clearly state the ratio of male:female participants of the remaining studies, 287 (68%) participants were female. Of the included articles, all but one, a Randomized Control Trial,[27] were observational, longitudinal studies.

A number of different measures were used to evaluate physical activity levels. Accelerometers

Table 1. Critical appraisal of all studies.

	Criteria	Arborelius[21]	Arbuthnot et al.[22]	Chatterji et al.[23]	de Groot et al.[11]	Delasotta et al.[24]	Harding et al.[25]	Heiberg[17]	Holstege[18]	Horstmann[14]	Lin et al.[13]	Macnicol et al.[26]	Oosting et al.[27]	Pugh[15]	Ries et al.[16]	Smith et al.[20]	Smith et al.[19]	Vissers et al.[29]
1.	Did the study address a clearly focused issue?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.	Was the cohort recruited in an acceptable way?	NC	✓	✓	✓	✓	✓	✓	✓	✓	✓	NC	✓	NC	✓	✓	✓	✓
3.	Was the exposure accurately measured to minimise bias?	✓	✓	NA	✓	✓	✓	NA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4.	Was the outcome accurately measured to minimise bias?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5a.	Have the authors identified all important confounding factors?	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
5b.	Have they taken account of the confounding factors in the design and/or analysis?	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
6a.	Was the follow-up of subjects complete enough?	×	NA	NA	✓	NA	✓	✓	✓	✓	NC	✓	✓	NA	✓	✓	✓	✓
6b.	Was the follow-up of subjects long enough?	✓	✓	NA	✓	✓	✓	✓	×	✓	✓	✓	×	✓	✓	✓	✓	✓
6c.	Was the characteristics of excluded participants examined?	×	NA	NA	×	NA	×	×	✓	×	NC	×	×	NA	×	×	×	×
9.	Do you believe the results?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10.	Can the results be applied to the local population?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11.	Do the results of this study fit with other available evidence?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓: yes; ×: no; NC: not clear; NA: not applicable.

Table 2. Participant demographics of included studies.

Article	Study design	Number of participants (Pre-op)	Age (years)	Women (%)
Arborelius[21]	Longitudinal study	25	65.3 ± 9.1	72%
Arbuthnot et al.[22]	Observational study	Not Clear	Not given	Not given
Chatterji[23]	Observational study	216	Not given	Not given
de Groot et al.[11]	Longitudinal study	36	61.5 ± 12.8	64%
Delasotta et al.[24]	Observational study	62	43.2 ± 5.5	Not given
Harding et al.[25]	Longitudinal study	44	69 ± 8.4	64%
Heiberg[17]	Longitudinal study	88	66 (64–68)	58%
Holstege[18]	Longitudinal study	55	72.7 ± 6.8	75%
Horstmann[14]	Longitudinal study	55	58.0 ± 9.0	51%
Lin et al.[13]	Longitudinal study	12		100%
Macnicol[26]	Longitudinal study	30	69 (57–85)	100%
Oosting[27]	Randomized control trial	15	75.0 ± 6.3	67%
Pugh[15]	Longitudinal study	1	62	Not given
Ries et al.[16]	Longitudinal study	30	66 ± 10	37%
Smith et al.[20]	Longitudinal study	226	66 ± 7.0	60%
Smith et al.[19]	Longitudinal study	105	68.2 ± 9.3	57%
Vissers et al.[29]	Longitudinal study	30	60.3, 13.0	63%

were used in three studies,[13,28,29] cardiopulmonary exercise test, an incremental exercise test to volitional exhaustion, used in three studies[14–16] and the 6-minute walk test was also used in three studies.[17,18,27] Two studies analysed secondary data sets.[19,20] A more detailed summary of measures used is presented in Table 3.

Clinical findings: Primary outcomes

For the primary outcome measures, change in physical activity, percentage of 24-hours spent walking were analysed from two studies using accelerometry.[11,29] These reported no statistically significant difference on pooled analysis between pre- and post-total hip replacement at six months follow-up (MD: −0.21; 95% CI: −1.36 to 0.93; $I^2=12\%$; $n=65$; Figure 2).

Three studies provided data on movement-related physical activity as measured with accelerometery pre- and up to one year post-total hip replacement.[11,13,29] These studies reported no statistically significant difference in pre- and postoperative results on pooled analysis at six months follow-up (MD: −0.08; 95% CI: −1.60 to 1.44; $I^2=0\%$; $n=77$; Figure 2).

Clinical findings: Secondary outcomes

For the secondary outcome measures, measures of physiological capacity, three articles used Cardiopulmonary Exercise testing, one evaluated this on a cycle ergometer[16] and two studies used a treadmill.[14,15] There was no statistically significant difference, between pre- and post-total hip replacement at a mean nine-month follow-up (MD: −0.24; 95% CI: −1.36 to 0.87; $I^2=0\%$; $n=76$; Figure 2).

Three articles measured the 6-minute walk test.[17,18,27] These reported no statistically significant different in pre- and post-total hip replacement results at a mean 23-week follow-up (MD: −60.85; 95% CI: −122.41 to 0.72; $I^2=84\%$; $n=113$; Figure 3). A subanalysis was conducted, excluding Oosting[27] as it was the only study that looked at exclusively over 65 year olds. This resulted in an increase in the 6-minute walk test from 60.9 m to 89.1 m (MD: −89.09; 95% CI: −136.40 to −41.79; $I^2=68\%$; $n=101$; Figure 4) up to one year postoperatively.

Table 3. A breakdown of selected physical activity measures given in included articles.

Authors	Physical activity measure	PA level preoperation	PA level postoperation
Arborelius[21]	$\dot{V}O_2$ while walking as fast as possible	$\dot{V}O_2$ 832, 219 ml/min $\dot{V}O_2$ 19.5, 6.5 ml/m WS 46.2, 14.6 m/min	Six months postop $\dot{V}O_2$ 839, 264 ml/min $\dot{V}O_2$ 18.1, 5.3 ml/m WS 48.4, 14.4 m/min
Arbuthnot et al.[22]	Change in golf performance questionnaire	Reported as a change see post	One year postop 54% improved 42% no change 4% detrition
Chatterji et al.[23]	Change in recreational and sporting activity	Reported as a change see post	One year postop 2 sports significantly increased ($p<0.05$) participation levels postsurgery walking and aqua aerobics, 3 decreased ($p>0.05$) golf, tennis jogging
de Groot et al.[11]	Accelerometer	Movement related activity (%24 hours) 8.7, 4.0 Walking (%24 hours) 6.3, 3.0 Upright (%24 hours) 20.7, 5.9	Three month Movement related activity (%24 hours) 9.1, 3.9 Walking (%24 hours) 6.8, 3.0 Upright (%24 hours) 20.5, 6.4 Six month Walking (%24 hours) 6.9, 2.8 Upright (%24 hours) 21.4, 6.3
Delasotta et al.[24]	PA questionnaire	See postoperation	33% increase in recommended 83.3% decrease in occasionally recommended 450% decrease in discouraged
Harding et al.[25]	Accelerometer	Median IQR Time engaged in sedentary activity% 84 (9.8)	Six months Median IQR Time engaged in sedentary activity% 86 (10)
Heiberg et al.[17]	6-minute walk Stair climbing test	6-minute walk (m) 401 (377-425)	Three month 6mwt (m) 437 (416–458) 12 month 6mwt (m) 512 (490–534)
Holstege et al.[18]	6-minute walk	317.9, 112.3 m	Six weeks ($n=39$) 313.8, 89.6 m 12 weeks ($n=37$) 380.4, 99.0 m
Horstmann et al.[14]	Standardised incremental stress test	$\dot{V}O_2$ max (ml/min/kg): 16.0 (15.0;17.0)	Six months post $\dot{V}O_2$ max (ml/min/kg): 16.0 (15.0; 17.0)

(Continued)

Table 3. (Continued)

Authors	Physical activity measure	PA level preoperation	PA level postoperation
Lin et al.[13]	Accelerometer	1 month pre THR Daily activity time% 55.6, 13.5	Six months post THR Daily activity time 57.2, 12.8
Macnicol et al.[26]	12-minute walk	12-minute walk Max 2.52, 0.14 SEM kph Mean 112.8, 3.0 SEM bpm	Three months mean 12-minute walk 121.9, 4.9 SEM bpm Six months 12-minute walk Mean 121.9, 4.4 SEM 4.4 bpm
Oosting et al.[27]	6-minute walk	340, 78	Six weeks 339, 69
Pugh[15]	CPEX treadmill	Speed 5 km/h $\dot{V}O_2$peak 1.2 L/min	Three months post speed 7 kmh $\dot{V}O_2$peak 1.9 L/min Nine months post 8 km/h $\dot{V}O_2$peak 2.4 L/min
Ries et al.[16]	CPEX	Peak$\dot{V}O_2$ml.kg.min^{-1}:14.7, 3.7 $\dot{V}O_2$atATml.kg^{-1}:10.4, 2.5	Six months post Peak$\dot{V}O_2$ml.kg.min^{-1}:15.2, 4.2 $\dot{V}O_2$atATml.kg^{-1}:10.1, 2.6 12 months post Peak$\dot{V}O_2$ml.kg.min^{-1}:15.4, 3.3 $\dot{V}O_2$atATml.kg^{-1}:9.6, 1.9 24 months post Peak$\dot{V}O_2$ ml.kg.min^{-1}:16.1, 2.9 $\dot{V}O_2$atATml.kg^{-1}:9.9, 1.8
Smith et al.[20]	Secondary data set analysis	Number of stairs climbed per week: 10 ± 24 Walking to work or pleasure (hours/week): 0.82 ± 1 Duration of total recreational activities (hours/week): 8.7 ± 7.0 Physical activity energy expenditure (Mets per week): 57 ± 34	Up to one year postop Number of stairs climbed per week: 14 ± 25 Walking to work or pleasure (hours/week): 3.3 ± 5.0 Duration of total recreational activities (hours/week): 5.5 ± 5.3 Physical activity energy expenditure (Mets per week): 59 ± 41
Smith et al.[19]	Secondary data set analysis	Total Physical Activity Score for the elderly: 136 ± 84	Up to one year Total Physical Activity Score for the elderly 12 months: 135 ± 85
Vissers et al.[29]	Accelerometer	Movement related activity (%24 hours) 14.1 (11.8, 16.5) Walking (%24 hours) 10.3 (8.5, 12.1)	6 month post Movement related activity (%24 hours) 12.9 (10.8, 15.0) Walking (%24 hours) 9.5 (8.1, 10.9)

THR: total hip replacement, 6mwt: 6-minute walk test, CPEX: cardiopulmonary exercise test, IQR: inter quartile range; PA: physical activity; WS: walking speed; SEM: standard error of the mean.

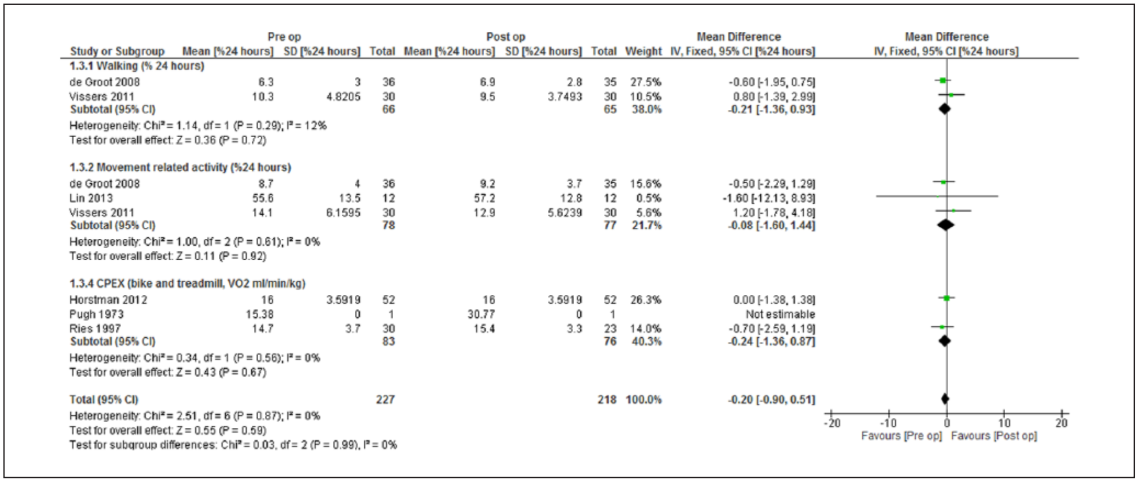

Figure 2. Meta-analysis of studies that used accelerometry or cardiopulmonary exercise testing (CPEX), fixed effect studies.

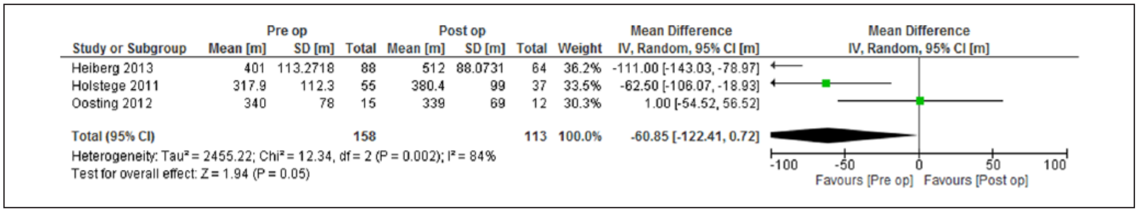

Figure 3. Random effects meta-analysis 6-minute walk test.

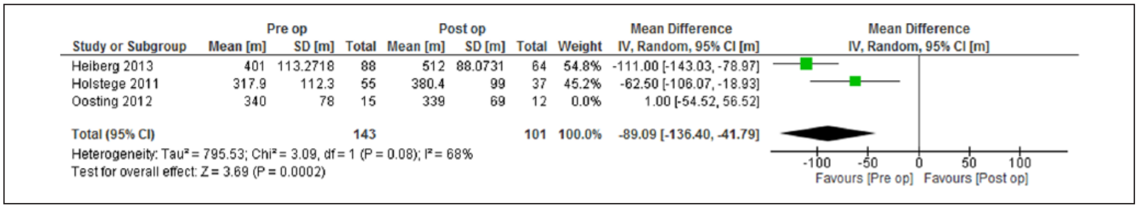

Figure 4. Random effects meta-analysis 6-minute walk test, removing Oosting et al.[27]

Discussion

The methodological quality of the research included within this review was generally low to moderate, as no study fully addressed all the Critical Appraisal Skills Programme (CASP) criteria. Only one study[18] examined the characteristics of the excluded participants, therefore providing limited information to ascertain if the data was representative of the total hip replacement population. Additionally, no authors attempted to identify confounding factors that may have influenced the level of physical activity that participants undertook. Therefore, it was not possible to appreciate whether cohort characteristics, such as pre-existing musculoskeletal pain, medical morbidities, age, gender or operative technique, influenced the results, as it may have been previously shown that rehabilitation is a key factor in improving outcomes post-total hip replacement.[30,31] Additionally, it is also important to consider the potential of timing of preoperative measure and its potential effect on outcome.

Postoperative data captured occurred between six weeks[18] to up to one year[19,22,23,32,33]. This therefore needs to be considered when drawing conclusions from this systematic review. However, as only two articles showed a significant improvement,[17,18] it is suggested that this is likely to have a minimal affect.

While the 6-minute walk test did not reach a statistically significant difference, it may be regarded as clinically significant with a mean difference of 60.9 m (95% CI: −122.4 to 0.7). Previous research in chronic lung disease suggests that clinically significant difference is 54 m (95% CI: 37 to 71 m).[34] Therefore, the 60.9 m improvement in patients following total hip replacement reported in our analysis could potentially represent a significant difference. There is no specific data for the total hip replacement population, but it is hypothesised that the clinically significant difference for total hip replacement patients is likely to be greater than patients with chronic lung disease as they have an aetiology that results in a physiological limited exercise capacity.

The 6-minute walk test data suggests that there was no significant difference between distances covered in the 6-minute walk test between pre- and post-total hip replacement. However, this result should be interpreted with caution as the meta-analysis demonstrated considerable heterogeneity ($I^2 = 84\%$). When the Oosting et al.[27] study was excluded alone (Figure 4), being the only study that exclusively recruited patients over 65 year olds, there was an increase in the distance walked between pre- and post-total hip replacement of 60.9 m to 89.1 m. This suggests that age may be a modifier of the 6-minute walk test result following total hip replacement. This finding should however be considered with considerable caution; as this is based on one study of 15 participants,[27] more research is needed to explorer this potential link. Additionally, studies in healthy populations have shown that age is a non-significant ($p > 0.05$) predictor of 6-minute walk distance[35] and there is no clear reason to suggest why there is a difference.

However, both pre- and postoperatively, the mean 6-minute walk test is noticeably less than the population mean. Heiberg et al.[17] was the article that showed the greatest distance pre- and postoperatively, 401 ± 113 m and 512 ± 88 m, respectively, though the reference values for 55–75 years old, is 659 ± 62 m.[35] This noticeable difference is suggestive that it is not purely the reason for the total hip replacement that may result in the decrease in 6-minute walk distance compared with the mean for the age group. There is therefore a need to understand better the other factors that may contribute to this decrease in physical activity in this population.

The previous methods of measurement discussed above could be referred to as 'non-laboratory' or 'free-living' based, that being that the measures have been undertaken in the natural environment and therefore not under controlled 'experimental' conditions.[36] However the cardiopulmonary exercise test does use 'lab-based' measures. It is important to note that while the cardiopulmonary exercise test may not be considered a measure of physical activity, as it is a measure of exercise capacity, it was included in this systematic review as it is an indirect, surrogate measure of physical activity.[36] This systematic review reported that there is no significant change in cardiopulmonary exercise test output between pre- and post-total hip replacement.

This study provides important information for healthcare professionals with regard to physical activity post-total hip replacement. Contrary to previous understanding, this systematic review does not support the hypothesis that patients are more physically active following total hip replacement. Instead, based on limited but available evidence, this systematic review reports that there is no change in physical activity following unilateral primary total hip replacement. Qualitative research suggests that when people prior to total hip replacement are asked what their activity aspirations are postoperatively, the most common goal is to return to the level of physical activity that they were undertaking before their hip disease or condition impacted on their lifestyle.[37] However, the results of this meta-analysis suggest that while this may be an aspiration, it does not consistently occur post-total hip replacement.[37]

As the benefits of regular physical activity are well documented and widely reported,[38] this systematic review suggests that a greater effort or new methods need to be developed to engage total hip replacement patients into becoming more physically active. Identifying barriers to physical activity engagement, and strategies to address these is therefore an important research to improve the overall health and wellbeing of this population.

To conclude, there appears no statistically significant change in physical activity between pre- and post-total hip replacements. However, the low to moderate methodological quality of the included studies should be considered when drawing such conclusions. Further research is warranted to better understand the changes in physical activity between pre- and post-total hip replacement and how people's perceptions of physical activity may be modified to increase engagement in physical activity.

Clinical messages

- Physical activity does not increase in the first year following total hip replacement.

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