Research and Best Practice - Review

Review: Does the amount of physical exercise before arthroplasty influence the postoperative outcome?

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Abstract

Background Clinical studies have evaluated a correlation between preoperative walking capacity or function and outcome after hip and knee joint replacement surgery with contradictory results. Our aim was to investigate the effect of preoperative metabolic and/or aerobic exercise on surgical outcome, as well as to evaluate the effect of cumulated exercise by using a cut-off value at 3.5 hours through a systematic review.

Methods The literature search was performed in Pubmed, Embase, and Cochrane Library databases. The inclusion criteria were randomised controlled trials, full paper publications, describing the preoperative exercise program and reporting outcome data. Exclusion criteria were inadequate randomisation, and unclear interventions or outcomes. The final literature analysis involved 12 studies. The review included meta-analyses on postoperative complications, specifically deep venous thrombosis, and length of stay.

Results The trials included 616 patients in samples sizing from 20 to 131. The duration of follow-up ranged from 12 to 96 weeks. The preoperative period of training ranged from 4 to 8 weeks; the number and duration of individual sessions varied from 9 to 56 and from 30 to 60 minutes, respectively. All trials reported one or more primary outcome. Meta-analyses were possible for postoperative complications and lengths of stay. Neither development of deep venous thrombosis, odds ratio 0.48 (95% CI 0.18 to1.25) nor the total complication was significantly reduced, 1.08 (0.64 to 1.86). The result for length of stay was –0.22 (-0.86 to 0.42).

Conclusion This review showed that preoperative exercise had no effect on the surgical outcome, neither overall nor for the cut-off value of 3.5 hours per week.

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Introduction

Joint replacement surgery is an effective operation to relieve pain and reduce disability in patients with severe hip and knee arthritis. These operations are used increasingly, and accordingly, attention is paid to programs in the perioperative period that would improve the outcome after surgery.

Major surgical intervention is often followed by a decrease in functional capacity and fatigue, which correlates well to the preoperative conditions, such as health status and muscle strength. Fatigue is also influenced by intraoperative factors like surgical trauma and stress-response (1). In recent years, several surgical disciplines have focused on optimal perioperative treatment-related procedures, such as Fast-track surgery (2). This concept operates with a multi-modal intervention aiming at an enhanced recovery, where the intraoperative procedures are optimised and combined with early post-operative mobilisation. The results have been positive, measured as reduced morbidity and early discharge; however, there is still room for improvement. Clinically, it would therefore be interesting to investigate whether adding preoperative optimisation of patients with training programs before the operation could further improve the outcome.

Studies have suggested a correlation between preoperative walking capacity or function and outcome after arthroplasty (3;4). The effect of exercise programs in the preoperative period has been evaluated in several randomised controlled studies. The results of the studies and the interpretation in reviews have been contradictory (5-19). This could be explained by the heterogeneity regarding training programs, which included different degrees of training intensity and duration, muscle strengthening and cardiovascular conditioning exercises. In addition, the outcome measurements and the follow-up varied among the studies. However, other explanations should be considered, such as the effect of cumulated amount of exercise.

The recommendation for the general population concerning physical activity includes both metabolic and aerobic fitness for 3-4 hours per week, or until metabolising about 2000 kcal per week (20;21). Thereby, any kind of exercise program would be effective, and the training programs of 3-4 hours or more per week may be more effective compared to shorter programs. This recommendation is based on population studies as well as patho-physiological studies regarding cardio-vascular, pulmonary, immune and muscular-skeletal functions (22;23); functions which are also important for the outcome after undergoing surgery. Hypothetically, the general recommended level of activity would also be effective for patients that are scheduled for surgery.

Our aim was to investigate the effect of preoperative metabolic and/or aerobic exercise on surgical outcome, as well as to evaluate the effect of cumulated exercise by using a cut-off value at 3.5 hours through a systematic review. The primary outcomes were postoperative complications and length of stay, functionality, pain and patient satisfaction, while patho-physiological parameters were secondary outcomes.

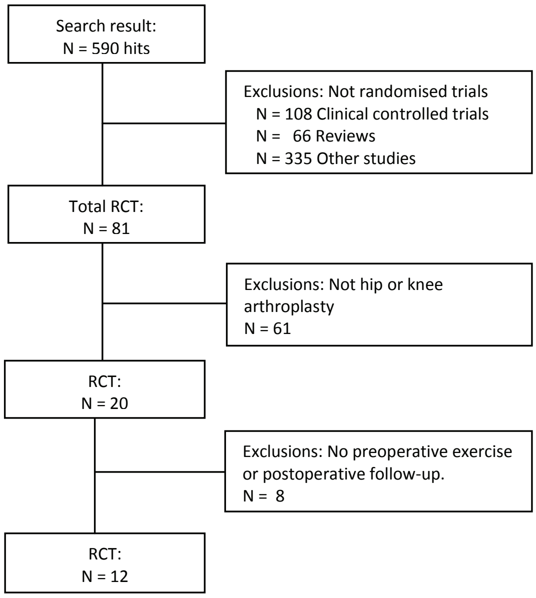
Methods

A systematic literature review was performed. The keywords were; (multimodal Rehabilit* OR activity OR exercise OR physiotherapy OR exercise movement techniques OR physical therapy techniques OR physical therapy OR training) AND (preoperative OR presurgical) AND (hip arthroplasty OR knee arthroplasty). The search was performed in Pubmed, Embase, and Cochrane Library databases. We limited the search to randomised controlled trials in humans. We also searched the reference lists of included trials and relevant reviews for additional studies. There were no language restrictions.

The inclusion criteria were randomised clinical trials, full paper publications, describing the preoperative exercise program and reporting outcome data. Exclusion criteria were inadequate randomisation, and unclear interventions or outcomes.

The title and abstracts were screened for relevant articles, which fulfilled the inclusion criteria, but not the exclusion criteria, see the trial profile in figure 1. Each study was evaluated regarding the quality (24;25).
The final literature analysis involved 12 studies (5;9-11;14;15;17;18;19;26-28).

Figure 1 Trial profile (RCT = randomised clinical trials)



Two papers (10;11) have previously been identified as publications on the same patient population (6). Nevertheless, both papers were included in the present review, since the authors reported different measurements. One study included both knee and hip arthroplasty, but differentiated between the procedures and results (17). It was therefore handled as two separate trials.
Among the excluded studies were those without physical training programs in the intervention groups (12;13;16;29;30).

Categorisation

The exercise sessions included cardiopulmonary exercise, muscle strengthening or both. They were further categorized into:

- Weekly exercise of 3.5 hours or more
- Weekly exercise below 3.5 hours

The accumulated exercise was calculated. If the duration of sessions was not given, it was estimated based on the information of the exercise program.

The outcome measurements were categorized into:

- Postoperative complications and length of stay
- Functionality measured by:
  - Walking capacity, walking speed, twenty meter walk test, six-minute walk test, timed up and go, WOMAC, AIMS, SF-36, Barthel Index, Harris hip score, Oxford hip score
  - Quality of life measured by quality of well-being
  - Patho-physiological parameters such as muscle strength, knee stability, ranges of motion, hospital-for-special-surgery-knee-rating-scale

Meta-analyses were performed regarding postoperative complications, specifically deep venous thrombosis, and length of stay. No further analyses were performed due to high heterogeneity in the other outcome measurements.

Results

The trials included 616 patients in samples sizing from 20 to 131. The short exercise programs included 432 patients of which 219 patients were randomised to the intervention groups and 213 to control groups; the longer programs included 184 patients (96 and 88 patients, respectively). The duration of follow-up ranged from 12 to 96 weeks.

All the 12 included trials performed intention-to-treat analyses. Two trials reported adequate allocation sequence generation; three trials reported adequate allocation concealment; four reported assessment blinding; and the remaining trials excluded dropouts from the final analyses. Only one trial reported adequate generation of allocation sequence, allocation concealment, blinded assessment, and intention-to-treat analyses 24. The methodological quality of the included studies was not high when assessed according to the criteria list recommended by the Cochrane Bone, Joint and Muscle Trauma Group (31;32) and the supplemental criteria from Jadad et al. (33) (table 1).

Time spent on exercise

The preoperative period of training ranged from 4 to 8 weeks, and the number and duration of individual sessions varied from 9 to 56 and from 30 to 60 minutes, respectively. The accumulated exercise time ranged from 6 to 32 hours, and the weekly exercise from 1.5 to 5.3 hours. Four trials exceeded the minimum limit for recommended exercise per week, (table 2).

Table 1 Methodological quality of included trials

Orthopaedic surgery	Country Study year	Was the study described as randomised?	Was the study described as double blind?	Was there a description of withdrawal and dropouts?	Was the assigned treatment adequately concealed prior to allocation?	Were the outcomes of the participant withdrawals described and included in the analysis (intention to treat)?	Were the treatment providers blind to assignment status after allocation?	Were the inclusion and exclusion criteria clearly defined?	Overall Quality
Weidenhielm L (1993)	Sweden (unknown)	Yes	No	Yes	No	No	No	No	Low
D'Lima DD (1996)	USA (unknown)	Yes	No	No	No	No	No	Yes	Low
Rodgers JA (1998)	USA 1992-1995	Yes Quasi re. geography	No	Yes	No	No	No	Yes	Low
Wang AW (2002)	Australia (unknown)	Yes	No	Yes	Yes	No	No	Yes	Low
Gilbey HJ (2003)	Australia 1997-1999	Yes	No	Yes	Yes	No	No	Yes	Low
Gocen Z (2004)	Turkey (unknown)	Yes	No	Yes	No	No	Yes	Yes	Low
Beaupre LA (2004)	Canada (unknown)	Yes	No	Yes	Yes	Yes	No/Yes	No	Low
Rooks DS (2006)	USA 2001-2003	Yes	No	Yes	Yes	Yes	No	No	Low
Vukomansovic A (2008)	Serbia (unknown)	Yes	No	Yes	No	No	No	Yes	Low
Ferrara PE (2008)	Italy	Yes	No	Yes	No	No	No	Yes	Low
Topp R (2009)	USA (unknown)	Yes	No	No	Yes	No	Yes	Yes	Low
Hoogeboom TJ (2010)	Netherland	Yes	No	Yes	Yes	No	Yes	No	Low

High quality = All criteria met (low risk of bias), Low quality = Not all criteria met (moderate or high risk of bias)

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Table 2 Description of randomised trials investigating preoperative rehabilitation programmes in relation to total hip or knee arthroplasty

							Preoperative training in the Intervention group (IG)						
Authors	Op	Postop rehabi-litation	Nº of Eligible patients	Incl. rate (%)	Patient (IG + C)	Drop outs (IG + C %)	Follow-up (weeks)	Exercises	Program duration (weeks)	Session duration (min)	Nº of Session (range)	Accu-mulated (hours)	Weekly (hours)
Ferrara PE	THA	Yes	63	37	11 + 12	2-9	12	LL Strength Stretch Bicycling Mobilities	4	30	12	6.0	2.5
Beaupre LA	TKA	No	-	-	65+66	12+21	12+24+48	LL Strength Bicycling	4	30	12	6.0	2.5
Hoogeboom TJ	THA	No	62	34	10+11	16+18	1	Strength Bicycling Functional	3-6	60	9 S+H	9.0	2.0
Topp R	TKA	Yes	54	68	26+28	-	4+12	Strength Stretch Aerobic	4	60	13 (4-23) S	13.0	3.3
Vukomannovic A	THA	Yes	-	-	23+22	13-9	1+60	Short term exercises and basic activities	-	-	-	-	-
D'Lima DD	TKA	No	-	-	(10+10)[1] +10	0+0	3+12+24 +48	Arm and leg cycling	6	45	18	13.5	2.3
Rodgers JA	TKA	No	-	-	10+10	9+16	6+12	LL Strength Stretch Bicycling Mobilities	6	45[2]	18	13.5	2.3
Rooks DS	TKA	No	942	5	23+23	35+26	8+26	Strength, Hydro-therapy, Aerobic, Bicycling	6	45	18	13.5	2.3
Rooks DS	THA	No	-	-	31+31	29+28	8+26	-	6	45	18	13.5	2.3
Gocen Z	THA	Yes	-	-	30+30	3+0	1+12+96	UL strength LL stretch	8	30[2] (3*10)	56	28	3.5
Weidenhielm L	TKA	No	-	-	19+20	0+3	12	Ergocycling	5	45[2]	35 S+H	26.3	5.3
Wang AW	THA	Yes	-	-	15+13	0+13	3+12+24	Strength, Hydro-therapy, Bicycling	8	60	32 S+H	32.0	4.0
Gilbey HJ	THA	Yes	127	44	32+25	19+32	3+12+24	Strength, Hydro-therapy, Bicycling	8	60	32 S+H	32.0	4.0

The dotted line shows the cut-off value of 3.5 hours training per week.
[1]Two intervention groups;
[2]Estimated from the description of the program
C = Controls, IG = Intervention group, LL = Lower limbs, Postop = Postoperative, Op = operation, THA = Total hip arthroplasty, TKA = Total knee arthroplasty, UL = Upper limbs, S = supervised, H = home sessions

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Effect
All trials reported one or more primary outcome. Meta-analyses were possible for postoperative complications and lengths of stay. The development of deep venous thrombosis was not significantly reduced 0.48 (95% confidence interval 0.18-1.25). The numbers were 1.09 (0.64-1.86) for the total complication and –0.22 (-0.86-0.42) for length of stay, (figure 2). One paper (26) reported length of stay but did not include the standard deviation and could therefore not be included in the meta-analysis. Due to the missing numerical data in the papers reporting results from the longer programs, it was not possible to analyse short-term versus long-term intervention studies.

There seemed to be a tendency of dose-response between time spent on exercise and the functionality measures such as walking tests; thus indicating a threshold at 3.5 hours per week or 26 hours accumulated.
The patho-physiological results were reported in 8 studies (9;15;17;18;19;26-28) and tended to be significant at a lower level of training; about 2.3 hours per week; however, the heterogeneity among the trials was too high to make these meta-analyses (table 3).

Discussion
This review showed that preoperative exercise halved the development of postoperative deep venous thrombosis among patients undergoing elective hip or knee arthroplasty; however, not to a significant level.
Furthermore, this review could neither accept nor reject the hypothesis of a cut-off value of 3.5 hours of cumulated preoperative physical training before surgery was related to the outcome, due to lack of measurable data.

This review had limitations, which were closely related

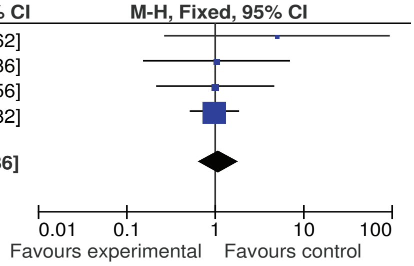
Figure 2 Meta-analyses

Any complication

Study or Subgroup	Preoperative training Events	Preoperative training Total	Standard care Events	Standard care Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Hoogeboom TJ	2	10	0	10	2.5%	5.00 [0.27, 92.62]
Gocen Z (1)	2	29	2	30	9.9%	1.03 [0.16, 6.86]
D'Lima DD	4	20	2	10	13.5%	1.00 [0.22, 4.56]
Beaupre LA	15	57	14	52	74.0%	0.98 [0.52, 1.82]
Total (95% CI)		**116**		**102**	**100.0%**	**1.09 [0.64, 1.86]**
Total events	23		18			

Heterogeneity: Chi² = 1.18, df = 3 (P = 0.76); I² = 0%
Test for overall effect: Z = 0.31 (P = 0.76)

Risk Ratio M-H, Fixed, 95% CI

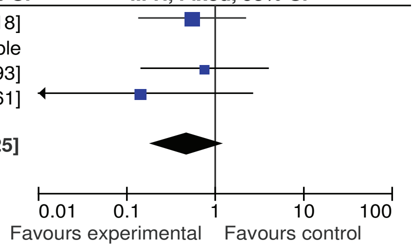


DVT

Study or Subgroup	Preoperative training Events	Preoperative training Total	Standard care Events	Standard care Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Beaupre LA	3	57	5	52	45.3%	0.55 [0.14, 2.18]
Rodgers JA	0	9	0	8		Not estimable
Rooks DS (a)	2	15	3	17	24.4%	0.76 [0.15, 3.93]
Rooks DS (b)	0	22	3	22	30.3%	0.14 [0.01, 2.61]
Total (95% CI)		**103**		**99**	**100.0%**	**0.48 [0.18, 1.25]**
Total events	5		11			

Heterogeneity: Chi² = 1.00, df = 2 (P = 0.61); I² = 0%
Test for overall effect: Z = 1.50 (P = 0.13)

Risk Ratio M-H, Fixed, 95% CI



Length of stay (days)

Study or Subgroup	Preoperative training Mean	Preoperative training SD	Preoperative training Total	Standard care Mean	Standard care SD	Standard care Total	Weight	Mean Difference IV, Fixed, 95% CI
Beaupre LA	10.2	4.5	57	11.7	5.2	52	12.3%	-1.50 [-3.33, 0.33]
D'Lima DD	6.2	1	20	6.1	1.1	10	62.9%	0.10 [-0.71, 0.91]
Vukomannovic A	9.8	2.4	20	10.2	1.7	20	24.9%	-0.40 [-1.69, 0.89]
Total (95% CI)			**97**			**82**	**100.0%**	**-0.22 [-0.86, 0.42]**

Heterogeneity: Chi² = 2.55, df = 2 (P = 0.28); I² = 21%
Test for overall effect: Z = 0.67 (P = 0.50)

Mean Difference IV, Fixed, 95% CI

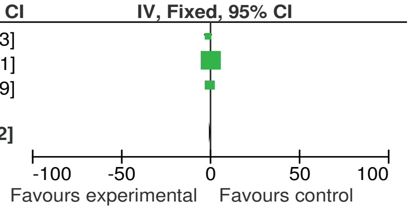


Table 3 Results of randomised trials investigating preoperative rehabilitation programs in relation to total hip or knee arthroplasty

						Functionality – integrated tests					
Aurthors	**Preop training weekly (hours)**	**Postoperative complications**	**Length of stay (days)**	**Quality of life**	**Pain**	**Walking Test**	**WO-MAC**	**SF-36**	**AIMS**	**Hip/ Knee scores**	**Others**
Hoogeboom TJ	2.0	NS Preop fract. All: 20% vs 0%	6.0 vs 6.0	NS	NS	NS	-	-	-	-	NS
Ferrara PE	2.5	-	-	NS	**Sign***	-	NS	NS	NS	NS	**Sign***
Beaupre LA	2.5	All: 27% (DVT 5 vs 10%)	10,2 vs 11,7	NS	NS	-	NS	NS	-	-	-
Vukomannovic A	(short)	-	9,8 vs 10,2	-	NS	**After 1 week***	-	-	-	NS	**Sign***
D'Lima DD	2.3	All: 20% vs 20%	6,1-6,3 vs 6,1	NS	NS	NS	-	-	NS	NS	NS
Rodgers JA	2.3	(DVT 0 vs 0%)	5 vs 6	-	-	NS	-	-	-	NS	NS
Rooks DS	2.3	(DVT 13 vs 17%)	-	-	NS	NS	NS	NS	NS	NS	NS
Rooks DS	2.3	**(DVT 0 vs 13%)***	-	-	NS	NS	NS	NS	-	-	-
Topp R	3.3.	-	-	-	NS	NS	-	-	-	NS	**Sign***
Gocen Z	3.5	(Infections 7 vs 7%)	-	-	-	-	-	-	-	**Sign***	**Sign***
Weidenheilm L	5.3	-	-	-	NS	**After 12 weeks***	-	-	-	-	-
Wang AW	4.0	-	-	-	-	**After 3+12+24 weeks***	-	-	-	-	-
Gilbey HJ	4.0	-	-	**Sign* Preop**	-	-	**Sign***	-	-	-	-

The dotted line shows the cut-off value of 3.5 hours training per week. If nothing indicated (-) = no results
All: all complications, DVT = Deep venous thrombosis, NS = no significance at any measurement, Preop = preoperative, Sign* = Significance at 0.05, sst = Sit to Stand Test, vs = versus

to the weaknesses in the individual studies. The drawbacks included small sample sizes, lack of power calculation, and sparse information on number of patients eligible for inclusion, excluded, drop outs, follow-up. The studies were not powered for evaluation of postoperative complications or other primary outcomes. The use of blinded assessor, intention-to treat analyses and correction for multiple significance tests were seldom. Furthermore, one study used quasi-randomisation based on place of residence. It all reduces reliability and hinders generalization of the results. All papers lacked information on the patients' training activities at inclusion and follow-up. The addition of an intensive postoperative exercise program only for the intervention group and participation in exercise in the control group (pre- or postoperatively) may have overshadowed any effect of the preoperative exercise program. Few papers presented information on validation of compliance of the intervention group; they used an exercise log book. The period between intervention and evaluation should be considered, because aerobic training is effective only a few weeks after quitting.

In four studies, the first visit was 3 months postoperatively, thereby increasing the risk of overlooking a significant effect in the earlier period (5;10;14;15).

In general, the papers included in this review showed a relatively low scientific quality when using the Jadad Score system (34). One might wonder, if the use of another score system may change the evaluation results of the study quality, but the Jadad Score System includes similar elements as general score systems accepted by the Cochrane Collaboration and (34). While double-blindness may always be a problem in this kind of interventions, other factors could relatively easy be improved; such as using intention to treat analyses and give clear inclusion and exclusion criteria. In order to bring the research on prehabilitation among surgical patients to a higher level of quality, we have to aim for better scientific performances.

It is obvious to measure the clinical outcome, as well as the physical function, in studies evaluating preoperative training programs (35). Nevertheless, in clinical trials the outcome measures should be clinically meaningful by inclusion of functional tests such as WOMAC, length of stay related to predefined milestones that should be reached before discharge, inclusion of all postoperative complications as well as convalescence defined as time until return to work or other activities. The choice of having surrogate data as the only outcome should be reserved for experimental studies. In this review, one study exclusively presented the total postoperative complications (18), while others were selected to present the prevalence of deep venous thrombosis (9;17) and infections (15), respectively. The rest gave no numeric data on their complication rates.

The possible long-term effect has not yet been evaluated for preoperative training programs.

In general, the complication rate and mortality are low in relation to knee- and hip arthroplasty, but age and co-morbidity are important risk factors for increased major complications (36;37). It would therefore be clinically relevant for especially elderly patients suffering from multiple co-morbidities, to become fit for surgery before the operation in an attempt to improve their outcome.

The time has come for performing high quality trials on the hypothetic effect of preoperative training programs. This should be done in a proper randomised design with a sizeable number of patients, possibly combined with optimised perioperative procedures known from the fast track surgery, with clear outcome measurements, and including long-term follow-up as well as cost-effectiveness analyses; the sooner the better. If no effect can be established, the resources are better used otherwise in health care. If an effect is established, the perspectives are tremendous for the individual patient, as well as for the health service systems due to improved outcome and on short-term, faster clinical pathways. A long-term effect could be a more active lifestyle than usual after arthroplasty, and thereby lesser development or progression of lifestyle related co-morbidity otherwise common in this patient group.

Contributors

P.R. Nielsen designed and managed the review, analysed and interpreted the data. H. Tønnesen designed the review and analysed and interpreted the data. P. Nielsen and H. Tønnesen wrote the paper, and approved the final edition.

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