A systematic review of randomised controlled trials was performed to evaluate the effectiveness of pre-operative physiotherapy programmes on outcome following lower limb joint replacement surgery. A search of relevant key terms was used to find suitable trials, with five papers meeting the inclusion criteria for the review. The methodological quality of the trials was rated using the PEDro scale. Estimates of the size of treatment effects were calculated for each outcome in each trial, with 95% confidence intervals calculated where sufficient data were provided. Of the three trials pertaining to total knee replacement, only very small mean differences were found between control and intervention groups for all of the outcome measures. Where confidence intervals could be calculated, these showed no clinically important differences between the groups. Two papers (one study) pertaining to total hip replacements found significant improvements in WOMAC scores, hip strength and range of movement, walking distance, cadence, and gait velocity for the intervention group, compared to a control group. Estimates of treatment effect sizes for these outcomes were larger than for the total knee replacement studies, with confidence intervals showing potentially clinically important differences between group means. However, as the intervention group also received an additional intensive post-operative physiotherapy program, these results cannot be attributed solely to the pre-operative program. This systematic review shows that pre-operative physiotherapy programmes are not effective in improving outcome after total knee replacement but their effect on outcome from total hip replacement cannot be adequately determined. [Ackerman IN and Bennell KL (2004): Does pre-operative physiotherapy improve outcomes from lower limb joint replacement surgery? A systematic review. Australian Journal of Physiotherapy 50:25–30]

Key words: Physiotherapy; Exercise; Outcomes Assessment (Health Care); Review Literature

Introduction

Total joint replacement surgery is an effective intervention used increasingly for severe hip and knee osteoarthritis. In 2000/2001, 17 108 primary total knee replacements (TKR) and 15 374 primary total hip replacements (THR) were performed in Australia, representing 10% and 8.3% increases respectively from the previous year (National Joint Replacement Registry 2002). The downside to this rise in the number of procedures performed is a simultaneous increase in waiting time for surgeries such as TKR, as seen in data published by the Australian Institute of Health and Welfare (Australian Institute of Health and Welfare 2001, 2003). In 2000/2001, the median waiting time for TKR and THR in Australian public hospitals was 114 and 95 days respectively (Australian Institute of Health and Welfare 2002). Many patients are on hospital waiting lists for lengthy periods; in 2000/2001, 19% of patients waited over one year for TKR and 12.3% waited over one year for THR.

It is common for patients to experience difficulty maintaining mobility and functional status whilst awaiting lower limb joint replacement surgery; these problems will increase if waiting lists lengthen. Accordingly, attention is turning to pre-operative physiotherapy programmes, and they have been introduced into several Australian hospitals already. These programmes are designed to enhance physical function and minimise patient anxiety before surgery, and to improve physical outcomes after surgery. Most programmes include exercise and education components but this paper will examine only the use of exercise programmes pre-operatively.

There is a variety of physical impairments associated with knee osteoarthritis compared to healthy elderly controls. This includes reduced quadriceps strength (Fransen et al 2002a, Hassan et al 2001, Hurley et al 1997) which has been associated with lower physical function (Ploutz-Snyder et al 2002, Hassan et al 2001, Hurley et al 1997). Significantly increased postural sway (Hassan et al 2001) and poorer dynamic balance (Hinman et al 2002) have also been found in this population. Significantly reduced hip strength, compared to age-matched controls, and marked muscle atrophy, compared to the contralateral hip, have been identified in people with hip osteoarthritis (Arokoski et al 2002). Severe cardiovascular deconditioning on exercise testing has also been found in patients awaiting TKR or THR (Philbin et al 1995). In addition to pain and stiffness, these impairments may help explain why this group has poorer physical and social functioning scores, compared to population norms (Kelly et al 2001).

Two recent observational studies have examined the effect of pre-operative functional status on outcome following THR and TKR. A large prospective study found that pre-operative pain and function is the best predictor of these variables at six months post-operatively, and that patients with poorer pre-operative physical function do not attain the same function or pain scores as those with better pre-operative function two years following lower limb joint replacement surgery (Fortin et al 1999, Fortin et al 2002); this was most evident for THR. Another large study (Holtzman et al 2002) found that patients requiring assistance with mobility and activities of daily living pre-operatively were significantly more likely to need assistance with these tasks one year after THR, compared to patients who were independent at
baseline. Therefore, whilst patients with poorer function and more pain before surgery have the potential for greater improvement following surgery, they do not appear to achieve the same end-point as patients with better pre-operative physical function.

Many randomised controlled trials (RCTs) have investigated the effects of exercise programmes for people with hip or knee osteoarthritis. The programmes have included various types of exercise (e.g. cross-training, aerobic, or resistance exercises) and different modes of exercise delivery (e.g. group versus personalised versus home-based programmes) with program lengths ranging from five weeks (Hurley and Scott 1998) to two years (Thomas et al 2002). Systematic reviews of these trials have reported small to moderate beneficial effects on pain (Petrella 2000, van Baar et al 1999) and small beneficial effects on self-reported disability (Petrella 2000, van Baar et al 1999) and physical function (Fransen et al 2002b). There has not previously been any systematic review of the effect of pre-operative exercise programmes on outcome from lower limb joint replacement surgery.

The aim of this paper is to systematically review the current literature on pre-operative physiotherapy for patients awaiting lower limb joint replacement surgery.

**Method**

**Literature search strategy** In August 2003, a search of the following databases was performed: MEDLINE (1966–2003), CINAHL (1982–2003), ISI Web of Science (1945–2003) and PEDro (up to July 2003). Combinations of the following search terms were used for all of the databases: knee, hip, joint, replacement, arthroplasty, surgery, exercise(s), physiotherapy, physical therapy, program(s), pre-operative, and surgical. The publication details of all RCTs involving exercise or physiotherapy programmes prior to knee or hip replacement surgery in any language were obtained. References listed in these papers were also examined for additional studies. All relevant trials were selected by one of the authors (INA) according to the selection criteria below.

**Selection criteria** In order to be included in this review, each study was required to:
1. Be a RCT
2. Be a full paper
3. Be written in English
4. Evaluate post-operative outcomes.

**Assessment of methodological quality** The criteria described in the PEDro scale (Moseley et al 2002) were used to rate the methodological quality of the RCTs. A review of the reliability and validity of these criteria can be found elsewhere (Maher 2000). Using this scale, the maximum total score for each RCT is 10 (as the first of the items is ignored for scoring). Each study was assessed by one rater who was not blinded to the author(s), journal, or the findings of the study.

Estimates of the size of treatment effects with 95% confidence intervals were calculated where sufficient data were provided in the original paper. Where sufficient data were not available, differences between group means were calculated. Where data were not provided in text form, they were obtained by measuring the graphs provided.

**Results**

**Included and excluded studies** Using the search engines, eight papers were identified which included reference to pre-operative physiotherapy and/or exercise programmes and hip and/or knee arthroplasty or replacement. Only five of these studies met the selection criteria for this review. The excluded studies were a retrospective analysis of the effect of pre-operative exercise and activity on functional outcomes following THR surgery (Whitney and Parkman 2002), a paper published in Dutch (Wijgman et al 1994), and a RCT involving multidisciplinary pre-operative rehabilitation (Crowe and Henderson 2003). This latter study involved therapies other than physiotherapy and the use of non-standardised physiotherapy treatment. After clarification by the corresponding author, it was found that subjects in one of the included trials (Wang et al 2002) were in fact a subset of subjects from a larger trial (Gilbey et al 2003), with subjects in the intervention group in each paper receiving the same intervention. However, as these papers reported different outcome measures, both have been included in this review. A total of 146 subjects were included in the five trials (the number of subjects in the subset described earlier are not included in this total).

**Methodological quality of the studies** Table 1 shows the RCTs that have been included in this systematic review, with trials ranked according to their total scores of methodological quality. The total scores ranged from 4 to 5 using the PEDro scale.

Three studies investigating the effect of a physiotherapy program before TKR or THR (Weidenhielm et al 1993, D’Lima et al 1996, Wang et al 2002) achieved a total score of five, the other two other studies (Rodgers et al 1998, Gilbey et al 2003) each scored four. Therefore all five papers are of a nominally similar methodological quality. As it is not possible to blind subjects or
therapists within these types of studies, all of the RCTs scored zero for both of these criteria. None of the studies reported the use of blinded assessors. All of the studies used no-treatment controls; no placebo control groups were used.

Three papers (Weidenhielm et al 1993, Rodgers et al 1998, Gilbey et al 2003) described subject withdrawals during the course of the trials (Table 2) but none of these papers reported the use of intention-to-treat analyses explicitly. One paper (Rodgers et al 1998) used quasi-random allocation to groups, with subjects living outside the local area assigned to the control group for practical reasons. There was no difference between the two groups at the pre-operative assessment for demographic data. The initial assessments for each group in this study were not performed at the same time; therefore prognostic similarity for the two groups cannot be determined and Criterion 4 was not satisfied. In the paper by Gilbey et al (2003), there were 19 subjects who dropped out of the study. This equates to only 75% follow-up for key outcomes and therefore Criterion 8 was not met. The study designs for each paper are provided in Table 3. Details of the outcome measures and interventions used can be found in Table 4.

### Efficacy of pre-operative physiotherapy prior to lower limb joint replacement surgery

It is not possible to aggregate results from the RCTs for statistical analysis due to the variation in outcome measures used and the lack of numerical data presented in some of the papers; instead estimates of treatment effect sizes have

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**Table 2. Subject characteristics.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Age mean (SD)</th>
<th>Sex F:M</th>
<th>Drop outs from study n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weidenhielm et al 1993</td>
<td>Intervention</td>
<td>64 (4)</td>
<td>11:8</td>
</tr>
<tr>
<td>Control</td>
<td>63 (5)</td>
<td>9:11</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>D’Lima et al 1996</td>
<td>Intervention A</td>
<td>68.5 (4.6)</td>
<td>7.3</td>
</tr>
<tr>
<td>Intervention B</td>
<td>71.6 (6.6)</td>
<td>2.8</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Control</td>
<td>69.5 (6.5)</td>
<td>5.5</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Rodgers et al 1998</td>
<td>Intervention</td>
<td>70 (range 63–78)</td>
<td>6.4</td>
</tr>
<tr>
<td>Control</td>
<td>65 (range 50–83)</td>
<td>5.5</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>Wang et al 2002</td>
<td>Intervention</td>
<td>68.3 (8.2)</td>
<td>9:6</td>
</tr>
<tr>
<td>Control</td>
<td>65.7 (8.4)</td>
<td>9.4</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Gilbey et al 2003</td>
<td>Intervention</td>
<td>66.73 (10.2)</td>
<td>21:16</td>
</tr>
<tr>
<td>Control</td>
<td>63.29 (12.0)</td>
<td>21:10</td>
<td>12 (38%)</td>
</tr>
</tbody>
</table>

**Table 3. Study designs.**

<table>
<thead>
<tr>
<th>RCT</th>
<th>Patient group</th>
<th>Assessment points</th>
<th>Groups (sample size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weidenhielm et al 1993</td>
<td>Unicompartmental TKR</td>
<td>All subjects Pre-op: 12 weeks and immediately pre-op Post-op: 12 weeks</td>
<td>Intervention 5 week group physiotherapy exercise program, 3 times per week (n = 19) Control standard care (n = 20)</td>
</tr>
<tr>
<td>D’Lima et al 1996</td>
<td>TKR</td>
<td>All subjects Pre-op: 6 weeks and 1 week post-op Post-op: 3, 12, 24 and 48 weeks</td>
<td>Intervention A 6 week customised physiotherapy exercise program, 3 times per week (n = 10) Intervention B 6 week customised cardiovascular conditioning program, 3 times per week (n = 10) Control standard care (n = 10)</td>
</tr>
<tr>
<td>Rodgers et al 1998</td>
<td>TKR</td>
<td>Intervention group Pre-op: 6 weeks and immediately pre-op Post-op: 6 and 12 weeks</td>
<td>Intervention 6 week customised physiotherapy exercise program, 3 times per week (n = 10) Control standard care (n = 10)</td>
</tr>
<tr>
<td>Wang et al 2002</td>
<td>THR</td>
<td>All subjects 25 m walk test Pre-op: 8 weeks and 1 week post-op Post-op: 3, 12, and 24 weeks 6 min walk test Post-op: 12 and 24 weeks</td>
<td>Intervention 8 weeks customised pre-op exercise program plus 9–24 week customised post-op exercise program, 2 times per week (n = 15) Control standard care (n = 13)</td>
</tr>
<tr>
<td>Gilbey et al 2003</td>
<td>THR</td>
<td>All subjects Pre-op: 8 weeks and 1 week post-op Post-op: 3, 12 and 24 weeks</td>
<td>Intervention 8 week pre-op physiotherapy exercise program plus 9 week post-op physiotherapy exercise program, 2 times per week (n = 32)* Control standard care (n = 25)*</td>
</tr>
</tbody>
</table>

### Table 4. Interventions and results.

<table>
<thead>
<tr>
<th>RCT</th>
<th>Exercises used</th>
<th>Home exercise program</th>
<th>Outcome measures</th>
<th>Main results: Differences between group means and 95% CI*</th>
</tr>
</thead>
</table>
| **Weidenhielm et al 1993** | Cycle ergometry, Lower limb mobilising, Lower limb strengthening | Daily | Pain, Passive knee ROM, Knee stability, Isokinetic quadriceps strength, Oxygen cost of walking, Walking speed | Pain on walking: 0.3 points (-0.8 to 1.4)  
Passive knee ROM: 5 degrees (-4.9 to 14.9)  
Quadriceps strength (peak): -9 Nm (-28.8 to 10.8)  
Oxygen cost: 0 ml/kg/min (0 to 0)  
Self-selected walking speed: -1.9 m/min (-7 to 3.2)  
Maximal walking speed: -3.2 (-10.2 to 2.8) |
| **D' Lima et al 1996** | **Intervention A**  
Lower limb stretches, Lower limb isometric and isotonic strengthening | No | HSSKR | HSSKR:  
3 (-6.3 to 12.4) for Control vs A  
2.2 (-7.3 to 11.7) for Control vs B  
-0.8 (-7.5 to 5.8) for A vs B  
% improvement in AIMS (no CI):  
6.3% for Control vs A  
-1.3% for Control vs B  
-7.5% for A vs B  
% improvement in QWBS (no CI):  
-9% for Control vs A  
-1% for Control vs B  
8% for A vs B  
HLOS:  
0.2 days (-0.7 to 1.1) for Control vs A  
0 days (-0.9 to 0.9) for Control vs B  
-0.2 days (-1.1 to 0.7) for A vs B |
| **Rodgers et al 1998** | Lower limb stretches, Lower limb mobilising, Lower limb strengthening, Stationary bike | No | HSSKR, Knee ROM, Isokinetic knee strength, Walking speed, Thigh circumference, Thigh muscle area on CT | HSSKR (no CI): 2  
Knee ROM (no CI): -2 degrees (extension), -4 degrees (flexion)  
Peak knee strength at 60 degrees (no CI):  
1 ft-lb (flexion), -3 ft-lb (extension)  
Walking speed (no CI): 1 sec  
Thigh circumference (no CI): 1 cm  
Thigh muscle area (no CI): 3.9 cm²  
HLOS (no CI): 1 day |
| **Wang et al 2002** | Pre-operatively  
Stationary bike, Resistive training machines for hip, knee and calf strengthening, Hydrotherapy  
Post-operatively  
Hydrotherapy, Progressive strengthening exercises, Aerobic activity | Twice per week | 25 metre walk test, Cadence, Stride length, Gait velocity, 6 minute walk test | Cadence: 9.0 steps/min (2.1 to 15.9)**  
Stride length: 0.1 m (0 to 0.1)  
Gait velocity: 0.2 m/sec (0 to 0.3)**  
Total distance: 64.6 m (3.7 to 125.5)** |
| **Gilbey et al 2003** | As for Wang et al | Yes | WOMAC, Hip flexion ROM, Isokinetic combined hip strength | WOMAC total score: -7.5 (-8.3 to -6.6)**  
Hip flexion ROM: 11.3 degrees (9.9 to 12.7)**  
Hip strength z-scores: 0.7 (0.6 to 0.7)** |

ROM: range of movement.  
HSSKR: hospital for special surgery knee rating (0–100 scale, 100 = perfect score).  
AIMS: Arthritis Impact Measurement Scale (0–30 scale, 0 = perfect score).  
QWBS: Quality of Wellbeing Scale (0.00–1.00 scale, 1.00 = perfect score).  
CT: computerised tomography.  
HLOS: hospital length of stay.  
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index (normalised to a 0–100 scale, 0 = perfect score).  
*negative score = lower score for intervention group vs control group  
**p < 0.05  
***p < 0.01.
been provided in Table 4 for each outcome where sufficient data were available in the original paper.

Only the papers involving subjects undergoing THR (Wang et al 2002, Gilbey et al 2003) found significant differences between the intervention group and the control group. This is reflected in the larger estimates of treatment effect size for these variables. Wang et al (2002) reported a significantly higher mean gait velocity for the exercise group from three to 24 weeks post-operatively, and a greater mean distance walked by the exercise group at 24 weeks post-operatively. Gilbey et al (2003) found that the exercise group experienced significantly larger mean gains in hip strength, WOMAC scores, and hip ROM from three to 24 weeks post-operatively. The three studies involving subjects awaiting TKR found no significant differences between groups post-operatively. Where sufficient data were provided in the published papers to calculate confidence intervals (Weidenhielm et al 1993, D’Lima et al 1996), it can be seen that these are narrow enough to rule out any meaningful differences between the groups. As the confidence intervals for all of these outcome measures include zero, the null hypothesis must be accepted. In one paper (Rodgers et al 1998) insufficient data were provided so that the size of treatment effects could only be estimated by calculating differences between group means. As there are extremely small differences between the groups for each outcome measure (with the control group out-performing the intervention group for some outcomes), this again appears to preclude any clinically worthwhile effect of the pre-operative intervention. The only significant finding by Rodgers et al (1998) was an effect of exercise on cross-sectional thigh muscle area.

Discussion

Two systematic reviews (Fransen et al 2002b, van Baar et al 1999) have found small to moderate beneficial effects of exercise for hip or knee osteoarthritis. Several clinical trials (Fransen et al 2001, Deyle et al 2000, Hurley and Scott 1998) have also shown the benefit of physiotherapy programmes in the management of knee osteoarthritis; however, very few trials have adequately assessed their effect on functional outcome following TKR and THR. The papers reviewed were found to be of similar methodological quality; all have design flaws which limit the interpretation of their findings.

One of the major drawbacks in the TKR studies reviewed was the use of very small sample sizes. Nonetheless, CIs for estimates of treatment effects were quite narrow. The only significant finding by Rodgers et al (1998) was an effect of exercise on cross-sectional thigh muscle area.

The appropriate selection of subjects is crucial for any clinical trial to ensure generalisation of results. The study by Weidenhielm et al (1993) involved subjects awaiting unicompartamental knee replacement (UKR), meaning that these findings cannot be applied to the TKR population. Patients receiving UKR are likely to experience a smaller decline in knee strength and physical function pre-operatively and to have a faster recovery from surgery, compared to TKR. The type of physiotherapy interventions used in the studies can also restrict generalisation of the results. The design of an intervention program in a clinical trial is of key importance. It should be reproducible, able to be implemented in a clinical setting, and based on best available evidence. A criticism of the study by D’Lima et al (1996) is that the program design would not be clinically feasible. The interventions were provided on an individual basis, yet in practice one-on-one treatments are unlikely to be cost-effective or practical with respect to staffing and resources. In this study, the treatment groups underwent either a strengthening program or a cardiovascular conditioning program. In practice, a comprehensive physiotherapy program would incorporate both components and it is likely that a combination of these interventions is required to improve treatment effect size and identify significant improvements in a RCT.

The choice of outcome measures used should also be questioned, with some studies disregarding the concept of specificity of training. In these cases, the outcome measures chosen are not related to the interventions used and would not be expected to change following intervention. For example, Weidenhielm et al (1993) used an intervention which focussed on knee mobilising exercises and lower limb strengthening, yet the outcome measures included walking speed and oxygen cost of walking. Similarly, the basic strengthening exercises and ergometry used by D’Lima et al (1996) may not translate to a change in function as measured by questionnaires such as the Arthritis Impact Measurement Scale. It is likely that specific functional exercises may need to be targeted to achieve this aim. The use of a subjective knee strength measure is also a limitation in this study. Rodgers et al (1998) assert that the measurement scales used in the above study are probably not sensitive enough to detect changes in strength and other parameters following physiotherapy, as they have not been designed for this purpose. They also acknowledge that the choice of an isokinetic measurement tool in their own study may not detect changes in strength adequately after an isotonic training program. It may be that outcome measures which assess more global parameters such as physical function are more sensitive to changes after a physiotherapy program which comprises other components in addition to muscle strengthening. The use of the WOMAC Index by Gilbey et al (2003) and measures of gait parameters and general endurance by Wang et al (2002) are good examples of outcome measures which can measure change in this population; other simple functional measures of mobility and balance could also be used.

Attention must also be given to the quality of the statistical analyses used in these studies. Of the three papers which describe the withdrawal of subjects during the course of the study, none of these explicitly used intention-to-treat analyses. In the study by Rodgers et al (1998), both groups included subjects who were transferred to inpatient rehabilitation post-operatively or received additional outpatient physiotherapy, yet these factors were not analysed as covariates. Extra post-operative physiotherapy treatment provided to the control group only may have overshadowed any effects of the pre-operative program. Participation in other forms of exercise, particularly for the
control groups, and other physiotherapy treatment for the knee or hip are also confounding factors which were not controlled for in any of the studies reviewed. If control subjects were permitted to participate in regular exercise programmes or receive ongoing physiotherapy treatment, they do not constitute a true no-treatment control group.

Finally, another major limitation of the studies reviewed was the lack of any cost-effectiveness data. The assessment of costs versus benefits obtained will become increasingly important in physiotherapy research as health care costs escalate and hospital budgets are further strained. Little is known about the cost-effectiveness of the interventions in the studies which reported significant results. Gilbey et al (2003) reported the cost of the intervention program per participant but did not collect data on post-operative costs. Rodgers et al (1998) collected data on hospital length of stay and physiotherapy utilisation but did not present the results of any cost-benefit analyses. None of the other studies used outcome measures relating to cost-effectiveness. While these studies are obviously small and may not provide generalisable results regarding cost-effectiveness, data pertaining to the use of post-operative physiotherapy services could have provided some preliminary information.

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References


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