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Methods for Optimising Patient Function After Total Hip Arthroplasty

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1. Introduction

Symptomatic hip osteoarthritis occurs in 3% of the elderly (Felson 2004) and is associated with poor general health status (Dawson et al. 2004). Treatment strategies for hip pain have traditionally involved conservative measures (analgesia, exercise, education, weight reduction) and surgical intervention (joint replacement) is the most effective treatment for end stage disease (Birrell et al. 2000, Di Domenica et al. 2005).

According to the National joint registry, the number of primary total hip replacements (THR) in England and Wales in 2008/2009 totalled 77608, which is a steady rise from the amount reported in 2007/2008 (73632) and 2006/2007 (51981) (National Joint Registry for England and Wales 2010). The average age of patients undergoing a primary total hip replacement is 66.7 years (SD 13.1) with females slightly older than males (average 68.4 years (SD12.4) vs. 65.8 years (SD 12.24) respectively) (National Joint Registry for England and Wales 2010).

As technology and surgical techniques for total hip replacement (THR) improve, patient expectations have also increased, including for an early return to normal physical function and activities (Wang, Gilbey & Ackland 2002). A reduced time between surgery and mobilisation has been found to have an influence in reducing length of stay and increasing patient satisfaction (Husted et al. 2008). This is particularly important due to the introduction of initiatives such as integrated care pathways, which have rapidly reduced the length of hospital stay following joint replacement with inpatient physiotherapy time also reduced (National Audit Office 2003). The median length of stay for THR patients according to data collated from a total of 125 acute trusts in England (2004-2005) was 7 days (interquartile range IQR 5-10) (Wilson et al. 2008).

Whilst THR generally resolves pain, function usually remains substantially sub-optimal. At 24 months following total joint arthroplasty, patients with low pre-operative function are five times more likely to require assistance from another person for their activities of daily living compared to those with high preoperative function (relative risk 5.2, 95% CI 1.9-14.6; (Fortin et al. 2002)). This protracted disability has detrimental economic, social and health consequences. Optimising function after surgery is therefore an important component of rehabilitation.

2. Predictors of outcome following total hip replacement

A recent prospective multivariate regression analysis of factors affecting outcome after THR has shown that the most important factor to influence outcome is the preoperative Western Ontario and McMaster Universities Osteoarthritis (WOMAC) physical function (PF) score (Wang et al. 2009). WOMAC is one of the most widely used disease-specific outcome instruments in people with osteoarthritis. The study by Wang et al identified three independent variables; pre-operative WOMAC PF score, gender and the presence of co morbidities as significantly affecting the WOMAC PF score at 1 year post-operatively. Previous studies have hypothesised that high preoperative functional status has a positive effect on outcome whilst others have suggested that it leaves little room for improvement in functional status (Montin et al. 2008, Roder et al. 2007, Young et al. 1998). Patients with better preoperative functional scores are likely to have higher postoperative scores, whereas patients with poorer preoperative scores are likely to experience greater improvements in function (Wang et al. 2009). Greater improvement in functional outcome are observed in male vs. female patients and this could be due to the fact that women are more likely than men to seek THR at the more advanced stages of their disease (Katz et al. 1994).

Patients with preoperative co morbidities are more likely to have a poorer short-term outcome in terms of physical function and this recent finding by Wang et al is consistent in the literature (Lubbeke et al. 2007, Roder et al. 2003, Wood, McLauchlan 2006). Patients with significant preoperative co morbidities have more inpatient complications such as hypotension, neuropathy, thromboembolic events, septicaemia, cardiac arrest, myocardial infarction, respiratory failure, and renal failure after THR than those who do not (Imamura & Black 1998). Patients with hip osteoarthritis with musculoskeletal co morbidities such as low back pain and osteoarthritis of the non-operated hip, have less long term functional improvement after THR (Nilsson et al. 2003). A combination of more pain pre-operatively, higher age and postoperative low back pain predicts a worse outcome after THR in WOMAC PF after 3.6 years of follow-up (Nilsson et al. 2003). Function and pain in patients with lower preoperative physical function does not improve postoperatively to the level achieved by those with higher preoperative function (Fortin et al. 1999).

Old age predicts a poor postoperative outcome after THR and this is consistent with the impression that older people with self reported conditions restricting mobility in addition to arthritic pain in the hip or knee are at higher risk of psychological distress and physical dysfunction (Nilsson et al. 2003, Hopman-Rock et al. 1997).

3. Muscle strength and its relation to function after total hip replacement

The most common preoperative complaints by patients who elect to have THR are pain and loss of mobility (Trudelle-Jackson, Smith 2004). It therefore follows that the most commonly reported outcomes of THR in the literature relate to pain relief and restoration of mobility (Trudelle-Jackson, Smith 2004). Outcome studies of pain reduction and range of motion restoration, usually conducted 3 to 6 months after THR, indicate an overall satisfaction by patients and physicians (Barber et al. 1996). Outcome studies performed at least 1 year after THR reveal that impairments and functional limitations persist in the absence of pain. Impairments that persist at least 1 year after THR include decreased muscle strength and postural stability on the side of the replaced hip (Trudelle-Jackson et al. 2002). There are reported deficits in muscle strength of the involved hip after THR of 10-21% when compared to the uninvolved hip at 1 year post-surgery (Trudelle-Jackson et al. 2002, Shih et

al. 1994). The atrophic changes that occur about the hip persist up to 2 years following THR and this is evidenced by increased fat infiltration (Rasch et al. 2009). There is a suggestion by the authors that earlier operation may prevent the development of these changes and that fatty infiltration may be reversed by intensive rehabilitation (Rasch et al. 2009).

Frail elderly persons with sarcopenia (degenerative loss of skeletal muscle mass and strength associated with aging) often undergo musculoskeletal-related surgery, and the hospitalisation-associated immobilisation further compromises the skeletal system, with potentially grave consequences (Suetta et al. 2004). Many elderly patients fail to regain their preoperative level of function and self-care (Sashika et al. 1996).

Immobilisation due to major surgery and hospitalisation can cause a severe decline in muscle mass, muscle strength and muscle function (Bloomfield 1997, Covinsky et al. 2003, Hill et al. 1993). Muscle strength declines 4% per day during the first week of immobilisation, making it very important that physical training is commenced as soon as possible after surgery (Wigerstad-Lossing et al. 1988).

Physical training can improve strength and functional performance in healthy elderly and frail nursing home residents (Harridge et al. 1999, Lexell et al. 1995). Supervised progressive resistance training (PRT) in the early post-operative phase has been shown to be effective in restoring muscle mass, contractile rate of force development, and functional performance than rehabilitation regimes based on functional exercises and electrical stimulation (Suetta et al. 2004). Strength training that is initiated 6 to 8 weeks or more than 6 months after hip surgery also significantly increases muscle strength (Sashika et al. 1996, Hauer et al. 2002). Recent studies suggest this is feasible in a supervised facility and that it offers an effective way of increasing maximal muscle strength in elderly postoperative patients with significant gains in muscle fibre size and pennation angle that resemble those typically seen in young healthy individuals (Suetta et al. 2008).

Gait dysfunctions and asymmetries, both pre-and post-THR surgery, are also evident in patients with unilateral hip osteoarthritis (Madsen et al. 2004). This is inherently dangerous because it is well known that gait dysfunctions or lower limb muscular weakness heighten the risk of falls especially when negotiating uneven terrain such as a step or a chair (Madsen et al. 2004). Dysfunction can also lead to reduced mobility, living independence, and physical activity levels (Galea et al. 2008)

4. Impact of aging on muscle

Aging and disuse are two of the main conditions leading to skeletal muscle atrophy in humans (Suetta et al. 2008). In both conditions, the loss of muscle mass leads to a decrease in muscle force production, and there may also be a significant additional contribution from changes in muscle architecture (Narici et al, 2005). The loss of muscle mass with aging accelerates from the sixth decade onward, partly owing to a decreased number of muscle fibres and also as the result of general muscle fibre atrophy (Lexell et al, 1991). Cross sectional studies indicate that type II fibres are more vulnerable to the aging process than type I fibres (Lexell et al, 1991) but other studies have found more marked type I atrophy (Frontera et al, 2000). Muscle mass has been estimated to decrease by 30% during the life span (Lexell et al, 1995) and maximal muscle strength is reduced as a result of aging by ~1.5% per year from the sixth decade onwards (Skelton et al. 1994). Muscle strength has also been shown to decrease approximately 50% from age 30 to 80 (Sinaki 2004). Marked alterations in muscle architecture potentially contribute to loss of muscle strength (Narici et

al, 2005) and muscle fibre pennation angle reduction of 10-13% in old compared to young individuals suggests this (Narici et al, 2003).

5. Exercise regimes for improving function

One hour of physical training twice a week increases the muscle strength in the quadriceps muscle by 21% and grip strength by 14% with not more than eight weeks of physical training (Heislein et al, 1994). Similarly, low to moderate physical activity during 16 weeks of physical training is associated with a 30-100% increase in muscle strength in both men and women while the bone mass (BM) at best increases by 3% (Ryan et al. 1994). There are reports that muscle strength increases by up to 200% even in octogenarians, a much larger increase than the 2-20% increases in muscle volume or the 1-2% increases in BM with a similar training program (Daley & Spinks 2000, Fiatarone et al. 1994, Lexell 1999, Province et al. 1995).

Women above age 60 who exercise with aerobics twice per week improve their balance, coordination and muscle strength (Lord et al. 1995). The muscle strength in the quadriceps muscle improved by 29% and the sway of the body was reduced by 6%, while the BM was unchanged during the intervention year. The most commonly used rehabilitation regimes for elderly individuals are based on functional types of exercises without external loading (Suetta et al. 2008), although this type of intervention does not prevent further muscle atrophy (Reardon et al. 2001). Resistance training is an effective method to induce muscle hypertrophy and increase muscle strength and functional performance in the elderly (Harridge et al 1999) and using it in the postoperative phase has been shown to be an effective method to restore muscle function in this group of patients (Hauer et al. 2002).

Progressive resistance training (PRT) by definition elicits positive health and performance adaptations by challenging the skeletal muscles with loads that can be lifted repetitively to the onset of neuromuscular fatigue, the point at which appropriate technique can no longer be maintained (American College of Sports Medicine, 1998). PRT sessions are optimal when followed by periods of recovery ranging from 48 to 72 h to allow for physiological super compensation (i.e. positive adaptation) (Cheema et al. 2007). To facilitate continued adaptation, training intensity (i.e. load) and volume (i.e. number of sets) are progressively increased, and exercises are adjusted as indicated throughout the training regimen, to attenuate the onset of a plateau in physiological adaptation. Once the physiological plateau has been reached, health and performance are maintained with continued training, which may involve periodical manipulations of the PRT variables, including training frequency, training intensity (load), training volume (sets), types of exercises, and time under tension per repetition (Cheema et al. 2007).

PRT is a well-established and safe exercise modality for individuals of all ages and fitness levels, including those afflicted with severe chronic illnesses (Fiatarone et al. 1994, Cheema et al. 2007). It is particularly efficacious for adult and elderly cohorts given its efficacy in counteracting sarcopenia, abating osteoporosis and helping reverse the physiological and functional impairments that accrue with age (Fiatarone et al. 1994).

6. The evidence for pre-operative exercise regimes

Appropriate exercise offers many benefits in treating the patient with osteoarthritis (Macera et al. 2003). Stronger, better-conditioned periarticular muscles, tendons, and ligaments have advantageous biomechanical effects on attenuating joint forces during movement (Felson et al. 2000). In more severe disease, which often leads to reduced mobility and disuse atrophy,

exercise can improve pain, muscle strength, cardiovascular fitness, self-efficacy, and function (van Baar et al. 1999).

Exercise is a cornerstone of rehabilitation following total joint arthroplasty and other surgical procedures (Eyigor et al. 2004). Using exercise in the pre-operative period has variable benefit. An improvement has been demonstrated in the preoperative functional status after a 6 week presurgical exercise program (water and land based strength training activities) in patients awaiting total hip and knee arthroplasty in comparison to patients having routine rehabilitation but this effect is not maintained after 8 and 26 weeks of follow up (Rooks et al. 2006). This fits in with a previous study by Wijnman et al (Wijnman et al. 1994), which reported that preoperative physical therapy and instruction were not useful for patients before total hip arthroplasty. In their sample of 31 patients, few differences were observed between the patients and control subjects on measures such as the visual analogue pain scale and the Harris hip score (Wijnman et al. 1994). More recent work by Gocen et al (Gocen et al. 2004) also showed that instruction and pre-operative physiotherapy is of no benefit in terms of improving outcome (measured with the Harris Hip Score and Visual analogue scale) after THR surgery.

A systematic review by Ackerman and Bennell (Ackerman & Bennell 2004) found that only two randomised controlled trials involving patients undergoing THR surgery demonstrated a benefit of performing pre-operative exercise. Both Wang et al (Wang, Gilbey & Ackland 2002) and Gilbey et al (Gilbey et al. 2003) used pre-operative stationary bikes, resistance training of the lower limb and hydrotherapy with post-operative hydrotherapy, progressive strengthening exercises and aerobic activity. Wang et al (Wang, Gilbey & Ackland 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 (Gilbey et al. 2003) found that the exercise group experienced significantly larger gains in hip strength, WOMAC scores, and hip ROM from three to 24 weeks post-operatively. The systematic review concluded that the major limitation of these studies was the addition of an intensive post-operative exercise program for the intervention group only, so it is impossible to determine which of the pre-operative regimes was responsible for the improvements seen. There is therefore a lack of conclusive evidence to justify the use of pre-operative regimes to optimise function after THR surgery.

7. The evidence for post-operative home or centre-based exercise regimes to improve function

Early targeted rehabilitation has been shown to reduce hospital length of stay without an increase in complication rates after THR (Iyengar et al. 2007). Exercise programs beyond the normal postoperative rehabilitation period have been shown to reduce pain and leg stiffness, improve physical function and lessen the chance of accidental falls in THR patients (Gilbey et al. 2003). A disadvantage of these programs is the need for patients to exercise under the supervision of professional staff at a hospital or rehabilitation centre (Galea et al. 2008). This makes program delivery expensive due to the high costs associated with supervision, treatment and transport (Galea et al. 2008). In addition, some THR patients are excluded because difficulties with mobility and transport to a centre exclude participation (Marottoli et al, 1992). Studies comparing home- and centre-based rehabilitation programs for THR patients have found no difference in WOMAC scores, complication rates and patient satisfaction after 3 and 12 months of follow up (Mahomed et al. 2008).

An important factor in both home and centre based regimes is the use of PRT. A systematic review performed by the author (manuscript submitted for publication) on level 1 evidence- (randomised controlled trials) for regimes for rehabilitation after THR found the use of PRT to be predictive of functional benefit, when measured either using objective measures such as muscle strength or subjective functional measures such as the WOMAC. These centre-based interventions (Hesse et al, 2003; Husby et al, 2009; Jesudason et al, 2002; Liebs et al, 2010; Suetta et al, 2004) were performed in the early period (<1 month following surgery) and the home-based interventions (Jan et al, 2004; Trudelle-Jackson et al 2004) were performed late (>1 month following surgery).

A limitation of the home-based interventions assessed in the literature is that follow-up does not extend beyond the end of the exercise interventions periods. Thus, it is not clear whether the benefits evident at the end of the exercise intervention are maintained in the longer term. The other obvious shortcoming is the lateness of the intervention in the home setting and consequently the failure to ameliorate or prevent the exacerbated loss of muscle and function after surgery. A recent systematic review by Di Monaco et al (Di Monaco et al. 2009) suggests that the difficulties in THR rehabilitation research are that there is a lack of multicentre clinical trials with large sample sizes to inform the design of optimal physical exercise programs.

8. Motivators and barriers to improving function through exercise

Routine physical exercise improves one's general physical health (Wang et al. 2002) decreases the risk of medical conditions such as coronary artery disease, diabetes, osteoporosis and hypertension (Bouchard & Despres 1995); reduces mental health concerns such as depression (Newson & Kemps 2007); and can prevent falls (Barnett et al. 2003). Recent research also suggests that physical exercise plays a role in the maintenance of cognitive vitality in older age (Colcombe et al. 2004).

A recent study has shown that specific motivators and barriers to exercise differ with age, education, gender, psychological and physical well-being and current level of exercise (Newson & Kemps 2007). People over the age of 75 are more likely to be motivated to exercise purely to maintain an active lifestyle than those aged 63 to 74 years, and medical problems are more likely to prevent them from engaging in exercise compared than their younger counterparts (Newson & Kemps 2007). Men were found to be more likely than women to be motivated to exercise for the challenging nature of exercise. On the other hand, women are more likely than men to report health concerns as a reason to exercise, and they are more likely to blame a lack of exercise facilities and exercise specific knowledge as factors to prevent them from exercising (Newson & Kemps 2007).

High-level exercisers find the challenge to exercise to be more of a motivator than their low level counterparts, who reported health concerns to be a more important motivator. Low-level exercisers also noted a concern that factors associated with exercise and a lack of facilities and knowledge about exercise prevented them from exercising (Newson & Kemps 2007). The authors conclude that intervention programs for older adults need to take into account the specific contextual factors of the individual. The average age of patients undergoing THR surgery in the UK is 66.7 years (National Joint Registry for England and Wales 2010). According to Newson et al, these patients (63-74 years old) view keeping their fitness (feel-good nature of exercise, enjoyment) as the most important motivator whilst the most significant barrier is situational i.e. having no one to exercise with, disliking exercising alone and adverse weather conditions.

9. Outcome measures for assessing function

The need for THR is predicted to grow by 174% between 2005 and 2030 (Kurtz et al. 2007). It is therefore important that patient outcomes after surgery are continuously monitored and reviewed, to improve practise and optimise outcomes after surgery (Wylde et al. 2009). Central to assessing the effectiveness of hip replacement in a clinical setting is choosing the appropriate outcome measure (Wylde et al. 2009). In orthopaedics, outcomes after surgery can be assessed using five different methods, namely radiographic analysis, implant survivorship analysis, surgeon-based outcome measures, performance-related assessment and patient reported outcome questionnaires (Wylde et al. 2009).

Performance related assessment involves assessing the individual as they perform a specific task that is evaluated in a standardised manner using predetermined criteria (Wylde et al. 2009). A recent review (Terwee et al. 2006) has found that 26 performance measures have been used to assess function in patients with lower limb arthritis or joint replacement including walking, stair-climbing and chair tests. A moderate correlation has been reported between the results of patient self-reported functional ability and performance measures (Stratford et al. 2003; Terwee et al. 2006). This could be because performance related tests may not reflect the true demands and exertions associated with activities of daily living (Wylde et al. 2009). Other limitations include the fact that they are time consuming and only consider physical function whilst neglecting other important domains of outcome such as pain, quality of life and general well-being (Terwee et al. 2006).

Generic Health	Disease specific	Joint-specific
Assess subjective general health status with comparisons across different disease states and treatment options e.g. SF36. Assesses 8 dimensions of health related quality of life (HRQoL): Bodily pain, physical role functioning, physical role limitations, general health, vitality, social role functioning, emotional role limitations and mental health.	Focus solely on symptom and disabilities relating to particular condition but are not particular to the joint of assessment. e.g. for Rheumatoid arthritis AIMS (Arthritis Impact Measurement Scale) which has 9 component scales which assess mobility, physical activity, social activity, social role, activities of daily living, pain, dexterity, anxiety and depression. For Osteoarthritis, Western Ontario and McMaster University Osteoarthritis index (WOMAC) which is a 24 item measure of pain, stiffness and function.	Specific to the joint of assessment and attempt to exclude the influence of co morbidities E.g. Oxford Hip score which is a short 12 item questionnaire specifically developed to assess functional ability and pain in patients undergoing hip replacement. The questionnaire displays good psychometric properties and has a larger effect size than other tools such as the SF36.

Table 1. Types of Patient Reported Outcome Measures (PROMs) (Bellamy et al. 1988; Brazier et al. 1992; Dawson et al. 1998; Jenkinson & Layte 1997; Meenan et al. 1980; Salaffi et al. 2005; Ware et al. 1992, 1996)

Surgeon based assessment tools such as the Harris Hip Score assume concordance between the view of patients and clinicians, which is an erroneous assumption across all healthcare settings (Wylde et al. 2009). Within Orthopaedics, a lack of correlation has been demonstrated between surgeon and patient ratings of pain, function and satisfaction after joint replacement (Anderson et al. 1996; Bullens et al. 2001). Whereas surgeons may judge the success of joint replacement on the range of motion, alignment and stability, patients may evaluate outcome in terms of vitality and ability to return to leisure activities (Wylde et al. 2009). This inconsistency between patient and clinician ratings of health has guided the development of rigorous validated patient-reported outcome measures (Wylde et al. 2009). Patient reported outcome measures (PROMs) are advantageous because they are a cost-effective, efficient and minimally intrusive method of collecting data on patients (Wylde et al. 2009). PROMS can be grouped into generic health, disease specific and joint specific (Table 1). A limitation of all PROMs is the issue of recall bias towards patients reporting the most severe and recent pain they have experienced (Jensen et al. 2008).

10. Areas that remain to be explored

Total hip replacement surgery provides good relief for patients' pain but fails to fully restore physical function. The impairment of muscle function that occurs in relation to aging is exacerbated by the impact of surgery and subsequent immobilisation. Pre-operative regimes to improve functional outcome have not been shown to be beneficial. Post-operative regimes on the other hand, if including PRT, appear to have a significant benefit on patient function following THR regardless of the timing of the intervention. Centre-based regimes are plagued with issues of high transport and supervision costs. Early home based PRT studies that are effective and safe; with adequate follow-up after THR surgery would potentially improve outcomes after THR at an affordable cost, and appear an important area for future research.

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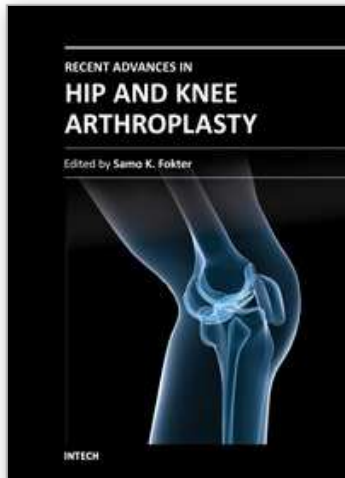
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The purpose of this book is to offer an exhaustive overview of the recent insights into the state-of-the-art in most performed arthroplasties of large joints of lower extremities. The treatment options in degenerative joint disease have evolved very quickly. Many surgical procedures are quite different today than they were only five years ago. In an effort to be comprehensive, this book addresses hip arthroplasty with special emphasis on evolving minimally invasive surgical techniques. Some challenging topics in hip arthroplasty are covered in an additional section. Particular attention is given to different designs of knee endoprotheses and soft tissue balance. Special situations in knee arthroplasty are covered in a special section. Recent advances in computer technology created the possibility for the routine use of navigation in knee arthroplasty and this remarkable success is covered in depth as well. Each chapter includes current philosophies, techniques, and an extensive review of the literature.

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