"*Falls risk and psychological variables (catastrophizing, depression, anxiety) in patients undergoing orthopaedic total joint (hip or knee) replacement*"

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A thesis submitted in fulfilment of the requirement of the Degree of Masters of Physiotherapy

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Sathiyapriya Gnanakumaran declare that this thesis is submitted in fulfilment of the requirements for the award of Masters in Physiotherapy, in the Graduate School of Health, Discipline of Physiotherapy at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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This thesis is presented in the format of Thesis by publication. Chapter 1 is the introduction chapter to the thesis. Chapter 2, representing the first half of the study, is a manuscript that has been prepared for submission. Chapter 3, representing the second half of the study, is a manuscript that is ready for submission to a peer review journal and Chapter 4 is the conclusion chapter of the Thesis.

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Ethics approval was obtained prior to the commencement of the research project through Sydney Local Health District Human Research Ethics committee CRGH (Reference number: LNR/17/CRGH/274; Ref: CH62/6/2017-190). The site-specific approval for CRGH Human Research Ethics committee was obtained (Reference number STE09606) and Ethics ratification was also obtained through University of Technology Sydney High Risk Ethics Committee (Human) as per requirement of the Masters Research Study (Reference number: ETH19-3410). The study protocol was registered with the Australian New Zealand trial registry: registration number ACTRN12618000334202.

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List of abbreviations:

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
CSRT	Choice Stepping Reaction Time
CCI	Charlson Comorbidity Index
HADS	Hospital Anxiety and Depression Scale
IQR	Interquartile range
LOS	Length of Stay
NSAID	Non-steroidal anti-inflammatory Drug
OA	Osteoarthritis
PCS	Pain Catastrophizing Scale
PPA	Physiological Profile Assessment
SD	Standard Deviation
SEIFA	Socio-economic Indexes for Areas
THR	Total Hip Replacement
TKR	Total Knee Replacement
TUG	Timed Up and Go Test
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index
6MWT	6 Minute Walk Test

Abstract

Evidence-based management of osteoarthritis (OA) has progressed over the past decades. However, there are still evidence gaps related to the management of osteoarthritis, particularly for surgical options for total knee replacement (TKR) and total hip replacement (THR) and the factors affecting the outcomes of these procedures. This thesis investigates the relationship of potential contributors affecting outcomes of surgical management in osteoarthritis patients.

A prospective cohort study of 100 participants who underwent TKR and THR surgery was undertaken. Chapter 2 reports on the role of previous falls, falls risk, and psychological (pain catastrophizing, anxiety, depression) and functional factors such as Timed up and Go Test (TUG) and Choice Stepping Reaction Test (CSRT) associated with post-operative outcomes of length of hospital stay (LOS), need for inpatient rehabilitation, and need for community support services at discharge. We found that the presence of high level pre-operative pain catastrophizing and depression, and pre-operative poorer function measured with TUG and CSRT, had positive associations with LOS. Pain catastrophizing and pre-operative falls were associated with an increased need for rehabilitation, and the CSRT with the need for community support services upon discharge.

Chapter 3 reports the change in falls, falls risk, and psychological factors prior to surgery to 6-weeks post-surgery. Of 100 participants described in Chapter 2, 68 participants completed the 6-week follow-up for this study. This study found that WOMAC, PCS, HADS scores improved from pre-and post- surgery of a total joint replacement. We found no differences on fall risk.

In summary, these studies showed that psychological factors, falls, and function are associated with post-operative outcomes of LOS, need for inpatient rehabilitation and services. The findings suggest the need for careful assessment and management of psychological factors, function, and falls in patients awaiting joint replacement surgery to improve pre- and post-operative outcomes. These findings empower clinicians and health managers to target relevant pre-operative factors and allocate resources appropriately leading to patient-centred care approach in patients undergoing TKR and THR procedures.

CHAPTER 1

1.0 INTRODUCTION

1.1 Overview

This thesis focuses on investigating the number of falls, the risk of falling, function associated with falling, and the psychological factors associated with falling in patients following total knee and total hip replacement surgery (TKR and THR). The main clinical indication for TKR and THR is osteoarthritis, a term coined by A.E Garrod in 1890 (Axford et al. 2010; Carr et al. 2012; Pivec et al. 2012). Osteoarthritis (OA) was the most common diagnosis requiring joint replacement surgery in Australia in 2018, (Australian Orthopaedic Association National Joint Replacement Registry 2019). In 2017-2018, 218 per 100,000 received TKR and 133 per 100,000 received THR with principal diagnosis of osteoarthritis in Australia (AIHW 2020). OA is the most common form of arthritis and the most prevalent chronic joint disease. It affects about 10% of men and 18% of women over the age of 60 (Woolf & Pfleger 2003). In Australia, approximately 1.6 million people were diagnosed with OA in 2007-2008 and this has increased to 2.2 million in 2017-2018 such that one out of every eleven Australians have OA and one in five >45 years of age have OA (AIHW 2010, 2019b). The number of people diagnosed with OA is also increasing in other economically developed countries. For example, in the USA, rates have increased at a rapid rate, from 31.2 per 100,000 in 1975-1976 to 220.9 per 100,000 in 2008 (Singh et al. 2010). Osteoarthritis often leads to pain due to the damage caused to the joint (Glyn-Jones et al. 2015), which can lead to loss of function. Osteoarthritis can develop in any joint with knee and hip being the most common (Bijlsma, Berenbaum & Lafeber 2011).

1.2 Pathology

Osteoarthritis is now known to be a complex condition that affects cartilage, subchondral bone, and synovium due, in part, to ongoing inflammatory processes (Glyn-Jones et al.

2015). In the early stages of OA, non-vascularised cartilage is not able to supply enough nutrients to chondrocytes which interrupts the healthy extracellular matrix that is vital for strong bones (Bijlsma, Berenbaum & Lafeber 2011). Clusters of chondrocytes are formed in the damaged area but unable to keep the balance, more degradation occurs. The extracellular matrix that is formed by the chondrocytes in this manner is unable to withstand normal mechanical pressures. Consequently, degradation of the extracellular matrix dominates this process and leads to tissue damage (Bijlsma, Berenbaum & Lafeber 2011). During this process, cartilage debris and catabolic mediators enter the synovial cavity leading to inflammation that perpetuates joint swelling and can result in pain (Bijlsma, Berenbaum & Lafeber 2011). Synovial macrophages produce catabolic mediators leading to more cartilage degradation and inadequate repair (Bonderson et al. 2006). This cycle further increases the inflammatory process, a by-product of which is ongoing nociceptor activation, which often leads to a chronic pain experience (Bijlsma, Berenbaum & Lafeber 2011). The diagnosis of osteoarthritis requires clinical assessment of ongoing pain, stiffness, and functional limitations combined with radiographic changes such as osteophytes, joint space narrowing, subchondral bone sclerosis, and cysts (Carr et al. 2012).

1.3 Management of Osteoarthritis

Osteoarthritis may cause pain, stiffness and decreased function leading to disability in patients with knee and hip OA (Wesseling et al. 2009). The initial treatment of osteoarthritis mainly involves managing the symptoms of pain and stiffness through conservative care (e.g., physiotherapy), and total joint replacement is usually deferred until end-stage disease (Carr et al. 2012; Pivec et al. 2012). Conservative management of OA as recommended by clinical practice guidelines includes pharmacological and rehabilitative interventions focusing on patient education, strengthening exercises, and

weight loss (Bijlsma, Berenbaum & Lafeber 2011; Misso et al. 2008). Pharmacological support through the use of paracetamol and non-steroidal anti-inflammatory drugs (NSAIDS) can be effective in the symptomatic relief of OA pain (Zhang, Doherty & Leeb 2007; Zhang, Nuki & Moskowitz 2008) and intra-articular corticosteroids injections to reduce flare ups of OA, although these tend to have only short term effects (Bellamy et al. 2006; Laupattarakasem et al. 2008). RACGP (Royal Australian College of General Practitioners) recommends patient education and multidisciplinary approach in the management of patients diagnosed with OA. These guidelines also recommend that patients should be referred for joint replacement surgery when all appropriate conservative treatments have failed (RACGP 2018). Managing OA symptoms with conservative methods has led to the development of programs in certain states in Australia such as the "Leading Better Value Care programs" supporting "Osteoarthritis Chronic Care program" (OACCP) to reduce pain, improve function, increase quality of life and promote self-management strategies to these patients (Agency for Clinical Innovations 2012). When patients do not respond to these measures and as the disease progresses with severe symptoms along with radiological evidence of end stage osteoarthritis, then surgical joint replacement is indicated (Della Valle & Rosenberg 2003). Although conservative methods of OA management can delay the option of undergoing surgical procedures, at some point for many patients conservative management fails, at which point surgical options including arthroscopy (Misso et al. 2008) and total joint replacement surgery (Dieppe et al. 1999) are recommended.

1.4 Total Knee and Total Hip Replacement surgeries

The first joint replacement procedures were carried out in the 1880s by Themistocles Gluck using ivory implants (Hernigou 2013). It took another sixty years from then for the development of successful hip prosthesis in the 1930s by Smith-Petersen and later by

Bohlmann and Moore in 1947 (Fischer et al. 2000). In 1960s John Charnley performed total hip replacements using a Teflon cup for the acetabular socket, metal prosthesis for the head of femur, use of bone cement, and several innovative techniques that became the basis for hip replacement to this day (Toledo-Pereyra 2004). Currently there are cemented, cementless, hybrids and reverse hybrid variations of THR and TKR prostheses and these prostheses have evolved significantly since the initial models 60 years ago.

The knee joint comprises three compartments: medial, lateral and patella-femoral. TKR can include the replacement of any one of the compartments of the knee with artificial components (Kerrigan & Saltzman 2017). The prosthesis replaces the proximal end of the tibia, the femoral condyles including the patellar groove, and the posterior surface of the patella. There is also a plastic spacer that fits between the replaced tibial plateau and femoral condyles. Partial or uni-compartmental knee replacement can also be performed with only the most damaged compartments of the knee being replaced. The hip joint comprises the acetabulum, the femoral head, and stem of the femur. THR involves the prosthetic stem, which fits into the femur; the ball, which replaces the head of the femur; and the cup which replaces the acetabulum.

1.5 Surgical approaches of TKR and THR

The surgical approach for TKR varies depending upon the degree of access to the knee joint while preserving the adjacent structures. The medial para patellar arthrotomy and anteromedial approach are the most two commonly used approaches for TKR surgery (Vaishya et al. 2016). The main three surgical approaches in THR surgery are anterior, direct lateral, and posterior approaches, although some variations occur (Kwon et al.

2006). The posterior approach is the most common surgical approach for THR (Moretti & Post 2017).

1.6 National joint replacement registries

National joint registries provide comprehensive information about knee and hip replacement surgery. The Swedish Knee Arthroplasty Register was one of the first registers which started in 1975. The national registries provide information on individual implants and information on other factors such as patient characteristics, surgical techniques, survival of the prosthesis, and revision times and rates (Robertsson et al. 2014). In the 1990s national registries started collecting patient reported outcome measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and quality of life questionnaires such as the Short Form-36 (SF-36) (Robertsson et al. 2014) as these factors were also recognised as important in the determination of success of TKR and THR procedure in patients.

1.7 The economic burden of TKR and THR surgery

There was a 105% increase in TKR and ~73% increase of THR surgery over the 10-year period of 2003-2013 in Australia (Ackerman, Bohensky, de Steiger, et al. 2017; Ackerman, Bohensky, Steiger, et al. 2017). There were 53,148 knee replacements and 32,156 hip replacements performed in Australia in the period of 2016-2017 (AIHW 2018a). It is projected that joint replacement will increase by 276% for TKR and 208% for THR by 2030 in Australia (Ackerman et al. 2019). THR is more common, with over one million procedures undertaken worldwide and the rates are increasing in more economically developed countries (Pivec et al. 2012). This steady increase in TKR and THR procedures places a large health cost burden on most developed health care systems.

Each THR or TKR surgery is estimated to cost around $AUD 19,000 to 30,000 per patient in Australia (Independent Hospital Pricing Authority 2017). The total estimated cost of TKR and THR in 2013 was $AUD 905 million and $AUD 625 million, respectively and the total cost of TKR and THR is estimated to reach $AUD 5.32 billion by 2030 (Ackerman et al. 2019).

1.8 Outcomes of TKR and THR surgery

TKR and THR are generally considered successful surgeries in relieving pain and disability in patients (Bourne et al. 2010; Judge et al. 2010). Early studies reported that TKR is a successful surgery based on the prosthesis-based outcome tools such as anatomical alignment of the prosthesis, prosthesis loosening, infection rates and prosthesis survivorship analysis (Ewald et al. 1999). Patient functional outcomes and quality of life measures such those measured by the WOMAC, Short form 8 (SF-8) and short form 36 (SF-36) have generally shown improvement after THR and TKR surgery (Cushner et al. 2010; Bruyere et al. 2012). However, while most patients have a good outcome following TKR and THR procedures, significant numbers of patients experience functional difficulties due to ongoing, persistent joint pain post-operatively. Importantly, up to 20% TKR patients (Bourne et al. 2010; Brander et al. 2003; Murray & Frost 1998) and up to 30% of THR patients (Judge et al. 2010) experience decreased function and persistent pain following their surgery. This is a substantial number of patients considering the sheer volume of TKR and THR surgeries performed. The failure of surgery to alleviate chronic pain associated with OA suggests that many patients require regular use of analgesics, including opioids to manage persistent pain (Bedard et al. 2017). In addition to persistent pain, the availability of support, complications of the surgery or of those in hospital after surgery, and other factors discussed below may

contribute to these patients continuing to experience disability, unemployment, and psychological distress.

In the light of ongoing pain and loss of function experienced by many patients following TKR and THR surgery, it has become important to shift the focus of what constitutes a successful outcome for these procedures from prosthesis based outcomes to patient centred outcomes such as pain reduction and improvement in quality of life using validated functional assessment tools (Wylde et al. 2007). In recent times, the outcomes of joint replacement surgeries have been based on patient reported outcome measures such as the Oxford Knee Score, WOMAC, Knee injury and Osteoarthritis Outcome Score (KOOS) and Hip dysfunction and Osteoarthritis Outcome Score (HOOS); and also on physical assessments such as Timed Up and GO (TUG) test, Sit To Stand (STS) test, and timed walk tests (Carr et al. 2012). In addition to this, outcome measures such as how patients perform after surgery in terms of complications in the post-surgery period, length of stay in the acute orthopaedic wards and in rehabilitation facilities, post-operative rehabilitation process and additional social support requirements have also become important as they impact on patient centred care and on the total health costs of these procedures. The factors affecting such patient related outcome measures has formed the basis of this thesis.

1.9 Factors that affect the outcomes of TKR and THR surgery

1.9.1 Age

Age is an important factor that affects the outcome of TKR and THR surgeries (Shah et al. 2019; Wylde et al. 2007). The average age of those receiving THR and TKR in Australia is 67.71 years and 68.18 years respectively (AIHW 2019b). Younger patients

(less than 50 years of age) report less improvements in pain and function and have a greater chance of revision surgeries (Julin et al. 2010). In contrast, post-operative complications and mortality increases in patients who are 65 years or older (Clement et al. 2011). However, Fitzgerald et al. (2004) noted that patients over the age of 75 have greater improvement in pain compared to the younger patients following joint replacement but their functional improvement was less. Thus, greater gains post-operatively may be seen in older patients because of greater pain and worse function before the surgery compared to younger patients. These results highlight the complexity in deciding the best time to have total joint replacement as there are advantages and disadvantages at any point.

1.9.2 Gender

Studies have shown that female gender correlates with poorer outcome after joint replacement surgery, with women experiencing lower physical function, reduced walking distance and requiring more assistance at one year following joint replacement surgery (Fitzgerald et al. 2004; Holtzman, Saleh & Kane 2002). In addition, women experienced more post-operative complications and longer length of stay compared to males after joint replacement surgery (Edusei et al. 2017; Weaver et al. 2003). It is not clear if females who have joint replacement surgery have more comorbidities which could explain this difference.

1.9.3 Socioeconomic status

People with lower socioeconomic status and those living in disadvantaged neighbourhoods are 42% more likely to self-report arthritis (Brennan & Turrell 2012). Socioeconomic status is inversely associated with prevalence of osteoarthritis and there

seems to be an extension of this relationship when it comes patients requiring TKR procedures (Brennan et al. 2014). Low socioeconomic status is associated with poorer outcomes post-surgery such as longer length of stay (LOS) (Shah et al. 2019). The reasons for this negative association are multifactorial and include greater comorbidities, poorer access to health care and poorer health education (Ultee et al.2018).

1.9.4 Ethnicity

Research has shown that there are ethnic differences in outcome after joint replacement surgery. Edusei et al. (2017) reported that people of non-white background are five times more likely to need rehabilitation services following TKR and THR procedures (OR=5.4, 95%CI= 2.4-11.8). Furthermore, a systematic review of TKR outcomes found that people of non-white background are more likely to have longer hospital stays (by up to one fifth of a day longer, Median=0.20, 95%CI=0.10-0.29) than those of white background (Shah et al. 2019). Like patients with low socio-economic status, it may be that patients from minority ethnic backgrounds lack optimal health information and social support networks leading to poorer post-operative results following these surgeries.

1.9.5 Comorbidities

The presence of comorbid health conditions such as diabetes, chronic obstructive pulmonary disease, previous wound infections, and number of comorbidities >1 on the Charlson Comorbidity Index (CCI) increased LOS in TKR and THR patients (Robbins, Rastrogi & McLaughlin 2014; Shah et al. 2019; Weaver et al. 2003). In addition, multiple joint pain related to OA is also a pre-morbid condition that is likely to lead to less satisfaction following joint replacement (Hawker et al. 2003). Despite these results, there is also evidence that patients who are older age with comorbidities had good functional

outcomes at six and twelve months post joint replacement surgery compared to their younger counterparts (Cher et al. 2018). This shows the need for careful consideration of age, comorbidities and pre-operative function when considering joint replacement surgery.

1.9.6 Obesity

Obesity is a preventable risk factor for OA (Felson, Anderson & Naimark 1998; Hart & Spector 1993) and yet, a large proportion of patients waiting joint replacement surgery are overweight. Le Mar & Whitehead (2014) reported 66% of the patients awaiting THR surgery are categorized as overweight with a BMI > 25. Furthermore, rising obesity rates can increase the need for TKR (Apold et al. 2014; Derman, Fabricant & David 2014; Leyland et al. 2016). Patients with high BMI have longer LOS (Prohaska et al. 2017; Shah et al. 2019), which increases heath care costs. A review of studies that looked at effect of obesity on the outcomes from Total knee arthroplasty found that poorer outcomes were reported in patients with a BMI greater than 30 (Rodriguez-Merchan, 2015).

1.9.7 Pain, pain catastrophizing, anxiety and depression

There is considerable empirical evidence now that the experience of pain does not have a simple relationship with tissue damage and there are somatic, psychological, and social factors that influence pain (Mosley 2007). There is agreement that the different pain reactions and responses and intensities observed in different people cannot be purely explained by physiological factors (Fordyce 1976; Turk & Rudy 1992). The biopsychosocial model for health psychology proposes the link between biological, psychological, social and macrocultural variables to conceptualise pain (Suls &

Rothaman 2004). This work by Suls & Rothman (2004) further supports the theoretical concept that chronic pain can be largely influenced by changes that increase the sensitivity of the peripheral and central nervous system (Gifford 1998). The Mature Organism model proposes that negative psychological states can alter physiological processes in the central nervous system perpetuating chronic pain and impairing health and recovery (Gifford 1998). More recently, depression, anxiety and pain catastrophizing have been identified as contributors and risk factors for chronic post-surgical pain (Giusti et al. 2021, Glare et al. 2019).

Pain catastrophizing and depression have been shown to be have negative impact on post-surgery outcomes in patients with TKR and pain catastrophizing alone was a significant predictor of daily pain levels and chronic post-surgery pain in these patients (Edwards et al. 2009). Anxiety and depression are very common in OA patients and, indeed, disability was associated in patients with greater anxiety and depression (Axford et al. 2010). Catastrophizing in response to pain, anxiety, and depression may alter coping mechanisms, leading to pain avoidance and thus, perpetuating chronic pain behaviour post-operatively (Ayers et al. 2004; Brander et al. 2003; Lingard & Riddle 2007).

1.9.8 Pre-operative Physical function

The extent of disability before surgery is an important consideration when examining post-operative outcomes. Pre-operative function measured with WOMAC, TUG, and 6 minute walk test (6MWT) predicts post-operative function at one week post TKR and THR surgery (Kennedy et al. 2002). Patients who were younger and less disabled pre-surgery were discharged within the average LOS expected for THR and TKR procedures (O'Brien 2002). Using meta-analysis, Shah and colleagues reported that

patients with poor pre-operative function (e.g., those requiring an assistive device for mobility compared to those that do not) had longer LOS following joint replacement surgery (Shah et al. 2019). In addition, patients with lower physical function as measured by Veterans Rand-12 physical component scores spent more than half a day (0.64 day) longer in hospital compared to those with higher function (Prohaska et al. 2017). This has a large impact on health-related costs. For example, in Australia, a half day increase in hospital stay can add $AUD 1,636 cost for the health system (AIHW 2018a). Pre-operative function not only affects short term functional outcomes and LOS, but it also affects long term outcomes of self-reported WOMAC scores at six months, one year, and two years following joint replacement surgery (Fortin et al. 1999; Lingard et al. 2004). While it isn't surprising that those who are functionally worse pre-operatively take longer to recover post-operatively, it stands to reason that improving pre-operative function may help improve post-operative outcomes after joint replacement surgery.

1.9.9 Falls and Falls risk

It has been established that knee arthritis is a risk factor for falling (Arden et al. 2006; Swinkles, Newman & Allain 2009). Osteoarthritis can cause pain and stiffness which can alter gait, reduce muscle strength, and affect balance and gait over time which all contribute to falls (Rubenstein 2006). The presence of ongoing pain has been shown to increase falls in the elderly population (Stubbs et al. 2014) and hence osteoarthritis related pain can increase the falls risk in this population. In one study, 24% of patients reported falling prior to TKR surgery and importantly, there was no improvement in balance confidence or function after surgery in these pre-operative fallers (Swinkles, Newman & Allain 2009). Physical factors such as reduced strength and poor balance are not the only causes of falling however, psychological factors also play a role. There is an association

between depression and falls, possibly due to the effects of depression on attention (Campbell et al. 1999; Rubesntein & Josephson 2002). Although pre-operative assessments are carried out routinely in patients awaiting TKR and THR surgery in public hospitals, there is no established protocol that pre-operative falls, falls risk, and psychological factors are screened in these patients. For patients requiring joint replacement surgery, physical and psychological factors associated with falls may affect post-surgical outcomes such as LOS, need for rehabilitation, and support services. However, this question has not been addressed in previous research.

1.9.10 Common Outcome Measures post TKR and THR

The post-operative timeframes and clinical outcomes that are routinely assessed following joint replacement surgery include short term recovery (outcomes within acute and sub-acute period up to six weeks), long term recovery (recovery after six weeks up to five years), pain level, quality of life, self-reported function, patient satisfaction, and task-based achievements such as improvement in knee range of motion. Research has demonstrated that while certain recovery milestones, such as time taken to achieve straight leg raise and time taken to achieve 90^0 knee flexion can affect discharge readiness in patients following total joint replacement surgery (Causey-Upton et al. 2019), other factors are also important such as post-operative pain (Beswick et al. 2012; Kennedy et al. 2006; Lingard et al. 2004; Lingard & Riddle 2007), psychological state (Lingard et al. 2004; Lingard & Riddle 2007) and patient satisfaction (Anakwe, Jenkins & Moran 2011; Dailiana et al. 2015).

1.9.11 Length of Stay

Length of stay (LOS) is a common hospital-based outcome that is used to inform protocols and monitor outcomes, particularly post-surgical rehabilitation pathways. The average number of days spent in hospital on the acute orthopaedic ward after undergoing TKR or THR is 4.5 days and 5.3 days in public hospitals across Australia, respectively (AIHW 2018d). Length of stay following these surgeries is of great interest to health policy makers and reformers, and health managers due to the cost associated with longer hospital stay and to clinicians for understanding the optimum discharge practice that influences patient flow and discharge planning. With increasing numbers of joint replacement each year, health systems seek to improve patient care at a lower cost. Reducing LOS in hospitals after these procedures is one method of reducing cost (Winemaker et al. 2015). Any reduction in LOS improves the hospital budget. Although TKR and THR surgery has improved with respect to surgical technique, prosthesis selection, and accelerated peri- and post-operative protocols, there are other patient related factors that affect LOS. Thus, studies have looked at factors that influence LOS after joint replacement and found that age, comorbidities, and obesity affect LOS (Le Mar & Whitehead 2014; Winemaker et al. 2015). Reducing LOS is not only financially useful to the health system, but also helps to implement effective discharge policies and organise adequate community support (O'Brien 2002). Age is the most significant factor that has an impact on LOS after total joint replacement surgery. For those patients undergoing total joint replacement aged >75years, LOS increases (Weaver et al. 2003; Winemaker et al. 2015). In addition, female gender, pre-existing comorbidities (such as cardiac and renal pathology, uncontrolled diabetes, and the presence of other musculoskeletal disorders) all are known factors that increase LOS in patients undergoing total joint replacement procedures (Winemaker et al. 2015). It is unknown whether falls, falls risk,

pre-operative function, or psychological factors also have an impact on LOS in patients undergoing joint replacement surgery.

1.9.12 Subacute services including inpatient Rehabilitation

With increasing TKR and THR surgeries per year, there are increasing demands for additional rehabilitation. Factors that may contribute to the need for extending rehabilitation stays therefore need to be examined. Patients who have not met the discharge criteria within the usual number of days of stay in the acute orthopaedic ward are likely to be transferred to an inpatient rehabilitation facility, rather than sent home, until they achieve various predetermined functional goals. The general functional discharge-to-home criteria for these patients after surgery include: knee flexion of 90 degrees or more for TKR patients, manageable level of pain, and independence in mobility (with or without supervision and with or without aid) and the ability to climb stairs with or without assistance (Chan Ee-Y et al. 2014; Illfeld et al. 2010). If patients fail to reach these goals, then additional rehabilitation is required and patients are transferred to a subacute rehabilitation setting, which, in Australia, can be an in-house dedicated rehabilitation ward or an external rehabilitation facility within the district. With older patients and those with more complex medical conditions undergoing joint replacement, there is an increased demand for rehabilitation after surgery like never before (Landry et al. 2007). Several patient characteristics are associated with the need for additional inpatient rehabilitation and include older age, living alone, and having co-morbidities (Forrest, Roque & Dawodu 1999; Kelly et al. 2000; Munin et al. 1995). Again, falls, falls risk, psychological and functional factors and their association with the requirement for inpatient rehabilitation have not been studied in this population.

1.9.13 Community Support Services

Community support services help meet the medical and social needs of the patient and/or their family on discharge from the hospital. These services can assist with activities such as self-care, household duties, shopping, transport, and gardening and are subsidised by the government through charitable organisations (Chan & Chan 2018). Community based post-acute discharge services have been established and used to reduce the pressure and costs on the hospital system (Hall et al. 2012). As age and related comorbidities are the main determinants of post-discharge community support service eligibility, healthy patients of age <65 are likely to miss out on some much needed social support services *My aged care*, an Australian Commonwealth home support program website, reports that in Australia, those under age 65 may not be eligible for community support services. Although community services vary widely across Australia, their aims are the same: to provide cost-effective functional support to individuals in their homes, including those recovering after TKR or THR surgeries.

1.9.14 Aims and objectives of the thesis

There are several patient-related factors such as age, gender, obesity, socioeconomic status and ethnicity, psychological factors (chronic pain, pain catastrophizing, anxiety, and depression) and physical factors (function, previous falls, falls risk) that affect TKR and THR surgery outcomes. It is also known that significant numbers of patient awaiting TKR and THR surgery experience falls before their operation. This thesis focuses on the link between psychological factors, persistent pain, and function and what effect they may have on falls and fall risk. It is unknown whether there is an association between pre-operative falling behaviour (number of falls, falls risk), the presence of psychological

factors such as depression, anxiety and pain catastrophizing, and outcomes from joint surgery.

Therefore, the first aim of the thesis was to investigate in patients undergoing TKR or a THR (Patients) whether there is any association between pre-operative falls, falls risk, physical function, and psychological functioning (Independent determinants), and post-operative outcomes of LOS, need for rehabilitation and for community support services (Outcomes). The second aim of this thesis was to determine whether there are any changes in psychological functioning, reported falls, falls risk, and physical function from baseline to six weeks post-surgery.

Chapter 2 of this thesis addresses the first aim by investigating the associations between falls, falls risk, psychological functioning and physical mobility factors on outcomes in patients undergoing TKR or THR surgery. To address the second aim, Chapter 3 reports whether falls, physical mobility, and psychological functioning change after surgery. Taken together, the findings of this thesis may provide a better understanding of the factors associated with patient-centred outcomes of total joint replacement surgeries which may contribute to the current research regarding these pre-operative factors and their effect on joint replacement surgery and recovery.

CHAPTER 2 Predicting hospital outcomes for total hip and knee replacement: falls, falls risk and psychological factors

2.0 ABSTRACT

Background: Total joint replacement surgeries are performed to improve patient pain and function, however many factors influence the outcomes of these procedures.

Objectives: To determine whether pre-operative physical and psychological factors predict post-operative length of stay (LOS) and need for rehabilitation and community support services following total hip and knee surgery.

Methods: A prospective cohort study was conducted with patients scheduled for primary joint replacement surgery over two years. Baseline data on number of previous falls, current falls risk, pain catastrophizing, anxiety, depression, and physical function were assessed. Discharge data on LOS, discharge destination and need for support services were collected. Univariate and multivariate regression analyses evaluated associations between predictor variables and outcome data.

Results: Participants were 100 joint replacement patients (mean age 66.9 years; 67% knee replacement). Pre-operative pain catastrophizing, depression, and physical function were positively associated with LOS (β between 0.04 and 0.14). Pre-operative falls rate and pain catastrophizing increased the probability of needing rehabilitation, and reduced physical function increased the probability of needing support services on discharge.

Conclusion: Falls, physical function, depression, and pain catastrophizing predicted poorer outcomes following total hip or knee surgery.

2.1 INTRODUCTION

Osteoarthritis of the knee and hip can lead to worsening symptoms such as persistent pain and declining function in patients. When these symptoms are not relieved by conservative treatment, surgical management is indicated that commonly results in total joint replacement surgeries. Total joint surgeries are increasing in Australia, with total knee replacements (TKR) increasing by 38% and total hip replacements (THR) increasing by 40% between 2005-2006 and 2016 -2017 (AIHW 2019b).

Patient satisfaction after undergoing TKR and THR surgeries is generally high, with about 80% of patients reporting satisfaction with their TKR and 76-91% reporting satisfaction after THR (Anakwe, Jenkins and Moran 2011; Daillana et al. 2015; Jones, Voaklander, &Johnston 2000; Wylde, Dieppe, Hewlett &Learmonth 2007). However, the 9-20% of patients undergoing these joint replacement surgeries who do not have a good outcome continue to experience significant problems with functional disability and psychological distress (Beswick et al. 2012). It is therefore critical to understand the factors that are predictive of poor outcomes following THR and TKR surgeries.

Chronic post-surgical pain can be a major source of dissatisfaction in this patient group, and several psychological factors are known to be predictive of persistent pain, including the presence of high pre-operative pain, pain catastrophizing, depression, and elevated general anxiety (Brander et al. 2003; Burns et al. 2015; Edwards et al. 2009; Pavlin, Sullivan, Freund & Roesen 2005). However, these factors do not operate in isolation, and there is evidence that they can also influence one of the major clinical concerns following joint replacement surgery, namely patient falls. Individuals with hip or knee osteoarthritis already have higher rates of falls compared to those without osteoarthritis (Tsonga et al.

2015; Hoops et al 2012; Manlapaz et al 2019) due to deficits in knee extension strength and reduced balance (Sturneiks et al. 2004). Furthermore, ongoing pain is known to increase the risk of falling by as much as 50% in community dwelling older adults (Stubbs et al. 2014). In addition to persistent elevated pain levels, psychological factors such as depression have also been identified as predictors of post-operative falls (Swinkles, Newman & Allain 2009). Depression can lead to inattention and poor activity levels and can become a mediator of pain causing falls (Swinkles, Newman & Allain 2009). These associations suggest that patients undergoing total joint replacement surgery with ongoing pain may be at greater risk for falls if psychological factors such as depression, anxiety, and pain catastrophizing are present pre-operatively. These factors can then impact key surgical recovery outcomes such as post-operative length of stay in the acute ward, the need for additional rehabilitation admissions and the need for additional social support services at discharge.

The average hospital length of stay (LOS) for TKR is 4.5 days and 5.5 days for THR in public hospitals across Australia (AIHW 2018a). Discharge readiness after total joint replacement is influenced by the patient's functional independence and their social support network (Causey-Upton et al. 2019). One of the key factors determining home as a discharge destination is functional independence (Lavernia et al. 2006; DeJong et al. 2009a; DeJong et al. 2009b; Chan et al. 2018; Benz et al. 2015). Patients that do not meet the discharge requirements for functional independence are more likely to require rehabilitation services and, once home, more community support services such as home nursing care (Mallinson et al. 2011). For patients undergoing total joint replacement procedures, research suggests that their psychological state, falls risk, and pre-operative functional levels can all play a role in how long they stay in hospital, and whether they

will need additional community support and rehabilitation services. Yet, little is known about the relationship between falls and these psychological variables, LOS and the need for additional support in patients undergoing total joint replacement surgery. Therefore, this study aims to investigate the association between psychological variables (i.e., pain catastrophizing, anxiety and depression), previous falls, falls risk (including functional mobility and balance), and common post-operative outcomes such as hospital length of stay (LOS), the need for additional rehabilitation, and the need for extra community support services post operatively.

2.2 METHODS

2.2.1 Study design

The overall study was a prospective cohort study with 6-week follow up. This paper describes the baseline and discharge data only from the overall study. Ethics approval was obtained from Sydney Local Health District Human Research Ethics committee (CRGH): LNR/17/CRGH/274; Ref: CH62/6/2017-190 and University of Technology, Sydney, Human Research Ethics Committee: ETH19-3410. This study was registered with Australian New Zealand Trial Registry (ANZCTR) number: (ACTRN12618000334202). This study conformed to the declaration of Helsinki.

2.2.2 Participants

All patients who were scheduled for primary TKR or THR surgery at Concord Repatriation Hospital in Sydney, Australia between March 2018 to January 2020 were eligible. In addition, they needed to be Australian citizens or residents, over the age of 18 years, on the waiting list for TKR or THR, and able to provide written informed consent

in English. Patients with known comorbidities that may affect recovery (e.g., severe respiratory or cardiac conditions) were excluded from the study.

2.2.3 Procedure

All participants were reviewed by the lead investigator (first author), and eligible participants were contacted by phone. After screening the participant and obtaining verbal consent to forward the study details, participants were mailed the participant information sheet, consent form, and the baseline questionnaire. Each participant was given a subject identification number to preserve anonymity. At the pre-admission clinic appointment (approximately 2-3 weeks before the surgery), the completed consent forms and questionnaires were collected by the investigator. Any questions or clarifications regarding the study were answered, and assistance was provided with completing any unfinished questionnaires as needed. The pre-operative baseline physical assessment data were then collected by the investigator as detailed below. Medical information such as past medical history and comorbidities were also collected from the medical records to check exclusion criteria.

2.2.4 Baseline, independent variables

Demographic information including age, gender, and postcode were collected as part of the baseline assessment at the pre-admission clinic. We used the IRSD (Index of Relative Socio-Economic Disadvantage) index of the Socio-Economic Indexes for Areas (SEIFA, 2016) to determine the socioeconomic status of patients based on the postcode (ABS, 2016).

At baseline we assessed four health questionnaires: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Bellamy et al. 1998), Pain Catastrophizing

Score (PCS) (Sullivan, Bishop & Pivik 1995), Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith 1983), and a falls questionnaire. Three baseline physical assessments were performed at the pre-admission clinic and included the Physiological Profile Assessment (PPA), the Timed up and Go Test (TUG), and the Choice Stepping Reaction Time Test (CSRT).

*WOMAC***.** This is a validated scale designed to assess pain, stiffness, and physical function of patients with knee and hip osteoarthritis (Bellamy et al, 1998). Scores range from 0 to 96, with low scores representing lower symptom levels and higher scores representing more severe symptoms.

The test-retest reliability of the WOMAC is high, with an Intra Class Correlation coefficient of 0.8 for the physical function subscale and > 0.7 for the pain subscale (McConnell, Kolopack & David 2001),

*Pain Catastrophizing Scale***.** This is a widely used instrument that measures three components of pain catastrophizing: rumination, magnification, and helplessness (Osman et al, 1997; Snaith, 2003). The PCS has good psychometric support; Cronbach's α scores (on total and subscale scores) range from 0.60 to 0.94, and test-retest reliability is acceptable (r = 0.70 to 0.75) (Pedler 2010). PCS scores can range from 0 to 52, where scores above 24 are considered indicative of significant catastrophizing and below 15 indicate non-catastrophizing (Sullivan, Bishop & Pivik 1995).

*Hospital Anxiety and Depression Scale***.** This scale is regarded a valid and reliable instrument for clinical and research use to identify anxiety and depression (Osman et al. 1997). The HADS has two subscales and the internal consistency (Cronbach's α) varied

between 0.68 and 0.93 for anxiety and between 0.67 and 0.90 for depression (Beekman & Verhagen 2018). In patients with osteoarthritis the HADS a sensitivity of 88% and specificity of 81% for anxiety and depression (Axford et al. 2010). The score can range from 0 to 21 for each anxiety and depressive symptoms. A score of 11 or higher out of 21 is a probable case of anxiety or depressive disorder (Snaith 2003).

Falls reporting Participants self-reported the number of falls experienced during three time periods: falls in the 12 months prior to surgery, falls during the pre-operative waiting period, and falls during post-operative period (period from hospital discharge to 6 weeks post-surgery). A fall was defined as the participant unexpectedly coming to rest on the floor without an external force (Lamb, Jorstad-Stein, Hauer & Becker 2005).

2.2.5 Physical Assessment

Physiological Profile Assessment (PPA). The PPA concerns a series of tests that take approximately 20-25 minutes to complete and assess falls risk through tests of vision, peripheral proprioception, muscle force, reaction time, and postural sway (Lord, Menz & Tiedemann 2003). PPA is used to differentiate between people who are at risk of falls (fallers) and those who are not (non-fallers). The scores are between -3 (low risk) to +3 (high risk). A web-based computer software program (www.fbirc.neura.edu.au) was used to assess the participant's performance in relation to a normative database (Lord, Menz & Tiedemann 2003). The PPA has a high level of accuracy (79%) for predicting falls in the older population (Lord, Clark & Webster 1991) and has been useful in discriminating deficits in lower limb strength, balance and proprioception in subjects with lower limb osteoarthritis to identify fallers (Sturneiks et al. 2004).

Timed Up and Go Test (TUG). The TUG is a performance test that assesses a participant's functional mobility (Podsiadlo & Richardson, 1991). The test requires the participant to stand up from a chair, walk 3 metres and return to a sitting position. The TUG has a high interrater reliability (interclass correlation coefficient (ICC) = 0.87), moderate test-retest reliability (ICC = 0.75) and a minimally detectable change of 2.5 seconds (Dobson 2015). It is a useful screening tool for predicting falls as it predicted fallers with 90% accurately when the participant took >13.5 seconds to complete the test (Shumway-Cook, Brauer & Woollacott 2000). Furthermore, the TUG is a highly sensitive (87%) and specific (87%) for identifying elderly participants who are likely to fall (Shumway-Cook, Brauer & Woollacott 2000).

Choice Stepping Reaction Time (CSRT). This test measures body weight and balance transfers required to avoid a fall (Lord & Fitzpatrick 2001). The CSRT requires participants to stand on a portable rubber mat and step quickly and accurately onto four targets for a total of 20 steps while being timed (Lord & Fitzpatrick 2001). The CRST has been shown to discriminate fallers (those with scores ≥ 22 sec) and non-fallers (scores of ≤ 19 sec) (Lord & Fitzpatrick 2001).

2.2.6 Outcome, dependent variables

Discharge data included information about hospital length of stay (LOS) in the acute orthopaedic ward (in days), need for rehabilitation after discharge from the acute orthopaedic ward, and any additional community support services requirements (such as community aged cares services, transitional aged care services and general community service packages). These data were collected from the medical records following

discharge. LOS is the primary outcome; secondary outcomes are the need for rehabilitation and community support services.

2.2.7 Statistical Analysis

Descriptive statistics (means, standard deviations, median, and interquartile ranges) were used to describe the study population and the outcome data. Univariate and multivariate regression models were used to evaluate the associations between the independent variables and the dependent variables: the number of days in hospital (LOS), the need for post-surgical rehabilitation (present/absent) and community support services (present/absent).

The assumptions for the regression analysis (linearity, homoscedasticity, independence, and normality) were tested prior to analyses. For all analyses, a p value <0.05 (two-tailed) was considered significant.

To create the prediction model, we selected the variables (p value <0.10) from the univariate analysis and applied them in a multivariate backward selection method. This was done only for LOS, as it was not possible to create prediction models for the need for rehabilitation and need for community services outcomes due to the small group sizes. Data analysis was performed with IBM Statistical Package for Social Sciences (SPSS) version 26 (IBM Corporation, New York) for Windows. To account for missing data, we used the worst-case simple imputation strategy (Donders, Van der Heijden & Moons 2006).

We used Welch Two Sample t-test to compare the baseline variables between TKR (67) and THR (33) patient groups and found no difference between the groups.

2.3 RESULTS

2.3.1 Participant characteristics

A total of 174 patients were screened during the 2-year period (March 2018- January 2020) and 118 patients were eligible to participate in the study. Of these, 11 participants had their surgery cancelled due to medical reasons and 7 refused to participate therefore, 100 participants entered the study: 48 males and 52 females (Figure 1). Of the participants 67 had TKR surgery and 33 THR surgery. The mean age of participants was 66.9 years (range: 40-91 years). Participants were of varying socioeconomic status based on the Socio-Economic Indexes for Areas (SEIFA) quantile (Table 1). We included the ABS Socio-economic index for areas (SEIFA), the Index of Relative Socioeconomic Disadvantage (IRSD) specific to a patient's postal area (ABS 2016). The IRSD is a composite measure of relative socioeconomic disadvantage, with a lower score indicating a higher proportion of persons of disadvantaged persons in the area, and a higher score a low proportion of disadvantaged persons.

Most patients (74%) had at least one or more comorbid medical conditions such as hypertension, hypercholesterolemia, diabetes, or other musculoskeletal conditions such as rheumatoid arthritis and gout (see Table1).

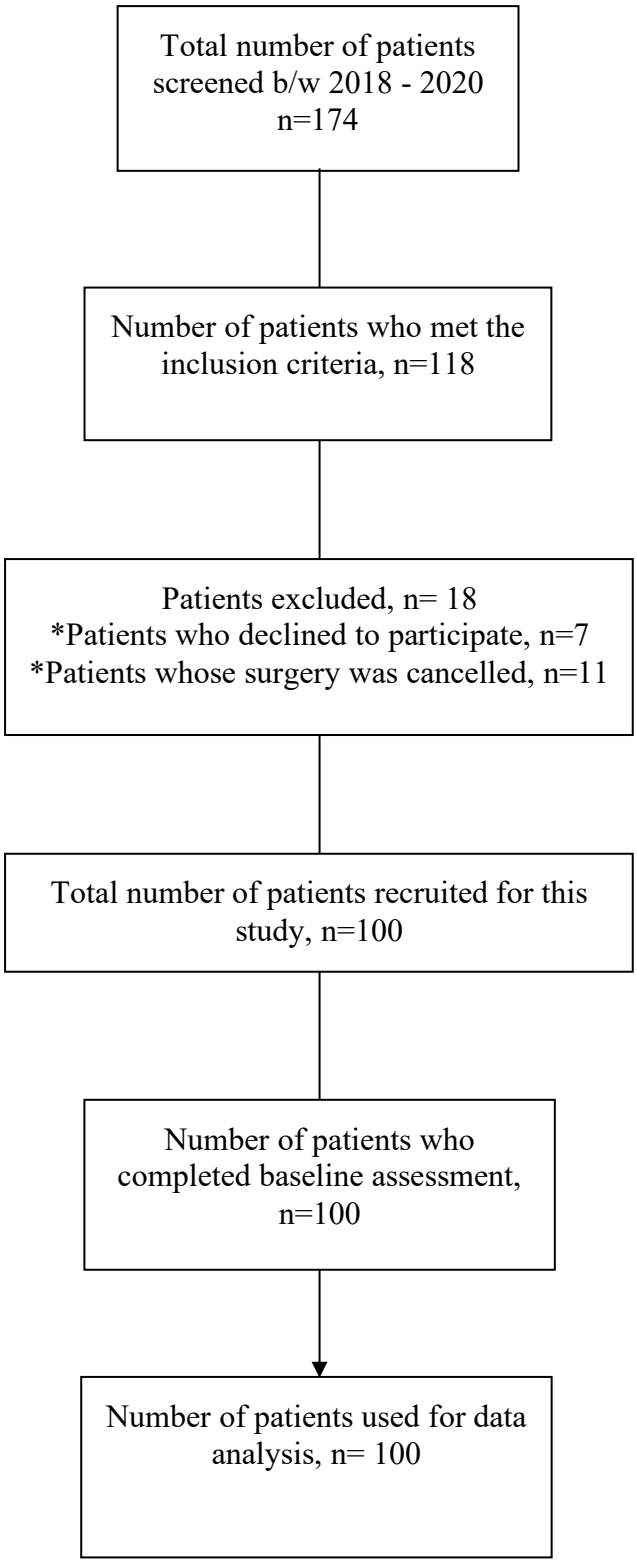

Figure 1: Flow chart of study participants (Study 1)

2.3.2 Baseline characteristics

Results for the pre-operative questionnaires and physical assessments can be found in Table 2. Overall, 37 participants reported high pain catastrophizing with PCS score >24, 56 participants had moderate to high falls risk (+1 to +3), and 76 participants had more than average functional limitations (≥50 WOMAC). In addition, 29 participants scored above the cut-off to indicate the presence of anxiety (≥11), and 19 for presence of depressive symptoms (≥11) on the HADS.

Table 1

Pre-operative characteristics of the sample population

Characteristic	
Total number	100
Gender = n (%)	
Male	48 (48%)
Female	52 (52%)
Age = Mean (± SD)	66.9 (±9.93)
Socioeconomic status = n (% of SEIFA quintile)	
1	23 (20.7%)
2	13 (11.7%)
3	11 (9.9%)
4	15 (13.5%)
5	38 (34.2%)
Comorbid health conditions = n (%)	
No comorbid health conditions	26 (26%)
At least one or more comorbid health conditions	74 (74%)

Abbreviations: SEIFA=Socio-Economic Indexes for Areas, quantile 1= the most socio economically disadvantaged, quantile 5= least socio economically disadvantaged (ABS, 2016).

Table 2

Pre-operative characteristics

Variables	**Median (IQR)**
PCS score	18 (7-35)
HADS Anxiety Score	7 (4-11)
HADS Depression score	7 (4-9)
WOMAC	59.50 (51-72)
TUG	14.19 (11.33-18.21)
CSRT	47.34 (37.50-52.51)
Number of Falls	**n (%)**
0	68 (68)
1	15 (15)
2	8 (8)
>3	9 (9)
Falls risk Score range (PPA)	
-3 to -1(Very low risk of falls)	3 (3)
0 to -1 (Low risk of falls)	11 (11)
0 to +1 (Mild risk of falls)	30 (30)
+1 to +2 (Moderate risk of falls)	30 (30)
+2 to +3 (High risk of falls	26 (26)

Abbreviations: IQR=Interquartile range; PCS=Pain Catastrophizing Score (>24 indicative of Pain catastrophisers); WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index (> 50 indicative of functional limitations); TUG=Timed Up and Go (>13.5 sec indicative of fallers); CSRT=Choice Stepping Reaction Time (>22 sec indicative of fallers). Anxiety and Depression scores of >11 indicative of anxiety and depressive symptoms.

PPA = Physiological Profile Assessment; > is greater than; % is percentage

Three participants were not able to complete the CSRT test due to pain during the pre-operative assessment. To account for missing values, we imputed the maximum recorded CSRT score from the data set (Donders, Van der Heijden, and Moons 2006). Overall, 32 participants (32%) reported having had at least one fall pre-operatively and the number of falls reported ranged from 0 to 12. The falls risk scores calculated from the PPA ranged

from −1.87 to +5.20. While 23% of the participants had 1 or 2 falls during the 12-month period leading to the surgery, more than half of the sample (56%) were in either the moderate risk (30%) or high risk (26%) of falls categories, based on their PPA scores.

2.3.3 Outcome

The mean length of stay (LOS) in the hospital was 4.40 days (SD = ± 2.67; range 1-15). Twelve participants required extended rehabilitation at discharge from the acute orthopaedic ward and 18 (18%) required community support services at discharge.

2.3.4 Associations

Length of stay (LOS). We found that pain catastrophizing was associated with LOS; LOS increased by 0.04 days for every unit increase in the PCS score. Depression was also associated with LOS (LOS increased 0.14 days for every unit increase in the depression score). Pre-operative function as measured with the TUG and CSRT were associated with LOS*;* with each increase in TUG and CSRT score there was 0.07 and 0.06 day increase in LOS, respectively (Table 3). There was no significant association between socioeconomic status and LOS (β = 0.20, 95% CI (-0.13- 0.53).

For the multivariate model we included pain catastrophizing, depression, TUG scores and CSRT scores. Depression and TUG scores remained in the model with an explained variance of 8.8 %.

Table 3

Univariate & multivariate associations

Variables	**Length of Stay** β *(95%CI)*		**Need for rehabilitation** *OR (95%CI)*	**Need for services** *OR (95%CI)*
	Univariate	**Multivariate**	**Univariate**	**Univariate**
Number of falls	0.18 (-0.14-0.49)		1.37 (1.02-1.83)	1.32 (1.00-1.74)
Falls risk score	0.28 (-0.12-0.67)		1.07 (0.69-1.67)	1.23 (0.85-1.79)
Falls	0.13 (-0.19-0.45)			
Falls risk score	0.24 (-0.17-0.65)			
PCS	0.04 (0.00-0.07)*		1.04 (1.00-1.08)	1.00 (0.97-1.04)
Anxiety	0.06 (-0.06-0.18)		1.05 (0.92-1.19)	1.00 (0.90-1.12)
Depression	0.14 (0.01-0.26)*	0.18 (-0.01-0.24)	1.07 (0.93-1.24)	1.06 (0.96-1.17)
WOMAC	0.00 (-0.03-0.34)		0.99 (0.96-1.03)	0.99 (0.96-1.02)
TUG	0.07 (0.01-0.13)*	0.21 (0.00-0.13)	1.02 (0.96-1.08)	1.01 (0.96-1.07)
CSRT	0.06 (0.01-0.11)*		1.05 (1.00-1.11)	1.08 (1.02-1.14)
Variance		8.8%		

*Entered into the multivariate model

Abbreviations: LOS=Length of Stay; WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index; TUG=Timed Up and Go; CSRT=Choice Stepping Reaction Time, PCS = Pain Catastrophizing Score

2.4 DISCUSSION

2.4.1 Main findings

We found that pre-operative pain catastrophizing and depression independently increased hospital LOS. In addition, pain catastrophizing and a history of falls were associated with an increased chance of needing additional rehabilitation services, and poor performance on a functional balance measure was associated with the need for additional community support services on discharge. A combination of depressive symptoms and poorer functional mobility significantly predicted how long patients would remain in hospital following their joint replacement surgery. However, our findings should be viewed with caution due to non-significant findings in the multivariate regression. Although there were significant findings in the univariate regressions, these should be interpreted cautiously as they do not capture all of the associated variance.

Our results indicate the presence of psychological factors such as pain catastrophizing and depression can significantly increase LOS after total joint replacement surgery, which results in additional clinician time and increased hospital costs. For each 10-unit of increase in PCS score and depression score there was a 0.4 day and 1.4 day increase in LOS, respectively. This means, for example, a patient who had a PCS score of 21 and a patient who had a PCS score of 41, the patient with the higher score is likely to have half day longer LOS after their joint replacement surgery. Based on the current inpatient hospital cost (AIHW 2018c), which shows each day of admission costs health care AUD$3272 per patient, a patient with a PCS score of 21 would cost the health care system approximately AUD$1308 (0.4 day of $3272/day) while a patient with a PCS score of 41 would cost the health system a total of AUD$4580 (1.4 day of $3272/day) per patient.

For patients with elevated preoperative depressive symptoms and higher pain catastrophizing scores, their longer hospital stay following surgery would result in additional staff time (i.e., caring for the patient) and resources (e.g., medications, meals, etc), which likely increases hospital cost. Both factors are potentially modifiable prior to surgery, and hence early screening and detection of problematic mood and pain cognitions may be warranted. Not all research has found an association between pain catastrophizing and LOS (Edusei et al. 2017; Kendell et al. 2001). It may be that it is the combination of unhelpful pain cognitions and low mood, as assessed in our study that is the critical factor. Further investigations into the effects of these variables in combination with other factors that influence length of stay are needed.

Those patients characterized as pain catastrophizers in our study also had an increased chance of needing further rehabilitation post-operatively. Previous research has also shown that pain catastrophizers took longer to achieve 90 degrees knee flexion after surgery (a key discharge criteria), suggesting that pain catastrophizers are slower at achieving their rehabilitation tasks (Kendell et al. 2001). This suggests that patients with high PCS scores may need further rehabilitation time after surgery, which underlines the importance of preoperative screening processes.

Our study showed that the time taken to complete the TUG and CSRT had a significant association with LOS. Moreover, poorer function as measured with the CSRT increased the chances of needing community support services on discharge. While previous research has demonstrated that poor pre-operative function is a predictor of poorer post-operative function (Kennedy et al, 2006; Lingard, Katz & Wright 2004; Fortin et al. 1999), few studies have examined the associations between pre-operative function and

LOS. Both tests are easily administered by a physical therapist and do not require extensive equipment or expertise. Taken together, our findings and those of others (Kennedy et al, 2006; Lingard, Katz & Wright 2004) seem to suggest that early screening may be of benefit to minimise additional hospital or community services. Replication of these findings with larger, more diverse patient groups is warranted.

We found that approximately 32% of participants had experienced a fall in the year prior to the surgery, and approximately 56% were in the 'moderate to high risk' of falling category based on their PPA score. This is consistent with other studies that show 31.4 % of the patients awaiting THR had at least one fall in the 12 months before their surgery (Ikultomo et al 2018) and 24.2% of patients awaiting TKR surgery fell prior to the surgery (Swinkles, Newmann & Allain 2009). In addition, our data showed that participants with more falls pre-operatively had 1.4 times more need for further rehabilitation. In patients with knee OA, decreased knee extension strength and proprioception has been associated with increased risk of falls (Sturneiks et al. 2004; Levinger et al. 2011). This could explain why patients in our study, who were identified as fallers, needed more time to meet the discharge criteria meaning: independence in mobility, stair climbing, and independence in self-care activities. This delay in meeting discharge readiness criteria may have contributed to the need for referral to additional in-patient rehabilitation rather home as a discharge destination.

2.4.2 Limitations

We did not measure factors such as the social support network of the participants (e.g., living alone vs living with an able-bodied partner) that may have influenced LOS, further rehabilitation requirements, and need for further community support services at discharge. The extent to which variations in surgical approach and surgeon experience may have influenced the outcomes is unknown. Finally, it is worth noting that while statistically significant, the combination of depressive symptoms and balance score only explained 8.8% of the variance in LOS, which suggests that there are other important factors that influence post-operative recovery time. Clear findings from the regression analyses were challenging due to the small sample size. Thus, the associations from the regression analyses should be viewed with caution because of unknown confounds and the potential for selection bias.

2.5 CONCLUSION

This study demonstrated that pain catastrophizing, depression, and pre-operative physical function are associated with greater LOS after total knee and total hip replacement surgery. Furthermore, pre-operative falls and pain catastrophizing were associated with the need for additional inpatient rehabilitation services, and poorer pre-operative function as measured by the CSRT was associated with the need for additional community support services after total hip and knee replacement surgery.

CHAPTER 3 Changes in falling behaviour physical and psychological functioning following total joint replacement surgeries: An observational study

3.0 ABSTRACT

Background: Falling is a common problem in older adults, and psychological factors such as pain catastrophizing, anxiety, and depression are associated with falls. People who have lower limb osteoarthritis have a high risk of falls.

Objective: This study aims to study the difference in falls, falls risk, physical capacity, and psychological functioning from baseline to 6-weeks post-operatively in people undergoing total hip replacement (THR) and total knee replacement (TKR) surgeries.

Methods: A prospective cohort study of people awaiting TKR or THR surgery with six weeks follow up. Out of the 100 patients at baseline, 68 completed 6-weeks post-operative assessment. Baseline and 6-week post-operative falls risk, number of previous falls, Timed up and Go Test (TUG), Choice Stepping Reaction Test (CSRT), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Pain Catastrophizing Scale (PCS), Hospital Anxiety and Depression (HADS) measures were collected and compared for the six weeks follow-up. Differences were tested using (paired t-test) and clinical relevancy was defined as a difference of 20% or more.

Results: Function and psychological factors improved statistically significantly from baseline to 6-weeks after a total joint replacement but failed to show a clinically relevant improvement. Falls risk did not improve post-surgery.

Conclusion: We found an improvement in physical and psychological functioning following THR and TKR surgeries, but no differences on fall risk.

3.1 INTRODUCTION

The number of total joint surgeries being performed in Australia are increasing, such that 38% more total knee replacements and 40% more total hip replacements were performed from 2005-2006 to 2016 -2017 (AIHW 2019a). Osteoarthritis is the primary cause for undergoing knee or hip replacement. Worsening of symptoms such as persistent pain, declining function, and increased numbers of falls, often leads to surgery with the general aim of improving quality of life for these patients.

Falls are one of the most common causes of injury, particularly among older adults, increasing risk of morbidity and mortality (Fuller 2000). The global burden of diseases for falls estimates that falls were ranked as the 17th and 25th leading cause of disability-adjusted life years in 2017 for males and females, respectively (Kyu et al. 2018). Falling has multiple potential causes including physical factors such as muscle weakness, balance problems, reduced range of motion of the knee or ankle, as well as psychological factors including depression, pain, and fear of falling (Leveille 2009; de Zwart 2015; Picorelli 2018, Chen 2019). For patients undergoing lower limb total joint replacement, fear of falling leads to reduced self-efficacy and impaired mobility, even after surgery has been done (Levinger 2011; Moutzouri 2017; di Laura 2018). Falls that occur in hospital after surgery can lead to increased length of stay (potentially doubling the time spent in hospital), which translates directly to increased health care costs and resources (Morello et al. 2015; Hill et al. 2007). In Australia, increased length of stay due to falls incurred mean additional hospital costs of AU$6669 (Morello et al. 2015)

As stated above, patients deciding to go forward with joint replacement often do so due to worsening persistent pain. Given the negative impact of persistent pain on quality of

life, it is not surprising that patients with OA also have an increased prevalence of depression (Gandhi, Zywiel, Mahomed & Perruccio, 2015; Lingard & Riddle 2007; Roseman et al. 2007). There is a strong, bidirectional relationship between persistent pain and depression (Edwards et al. 2009; Lewis et al. 2015). Those with persistent pain and symptoms of depression often also report pain catastrophizing, which is characterized by interpreting pain in an alarmist way, having greater feelings of helplessness, and actively ruminating or paying more attention to pain (Jensen et al. 2011; Keefe et al. 2004). Collectively, patients with worse pain, greater depression and high pain catastrophizing are more psychologically distressed; and in combination with reduced levels of physical function, are likely to be at greater risk of falling (Lingard & Riddle 2007).

The evaluation of peri-operative falls in lower limb total joint replacement is understudied. One recent scoping review found that patients awaiting total joint replacement surgery had on average, more falls (23-63%) compared to the number of falls post-surgery (13-42%) (Chen 2019). However, relatively few studies have examined the predictors of pre-operative falls, and thus, little is known about the pattern of falls and fall risk factors (Chen 2019). Investigating the differences of risk factors for falls such as pain catastrophizing, depression, and anxiety in this population may help identify those at a higher risk of falling and thus, provide insights into the interventions needed to mitigate the adverse effects of falls.

Therefore, this study aims to describe differences in falls, falls risk, psychological functioning (pain catastrophizing, anxiety, and depression), and functional mobility pre- and 6-week weeks post-surgery following total joint replacement of the knee or the hip.

3.2 METHODS

3.2.1 Study design

This was a prospective cohort study with a 6-week follow-up. Ethics approval was obtained from Sydney Local Health District Human Research Ethics committee (CRGH): LNR/17/CRGH/274; Ref: CH62/6/2017-190 and University of Technology, Sydney, Human Research Ethics Committee: ETH19-3410. This study was registered with Australian New Zealand Trial Registry (ANZCTR) number: (ACTRN12618000334202). This study conformed to the declaration of Helsinki.

3.2.2 Participants

Given outcomes and protocols are similar for THR and TKR (DeJong et al. 2009a; DeJong et al. 2009b; van der Wees et al. 2017; Wainwright et al. 2020) the criteria for patient selection were broad, with the aim of capturing patient variation to enhance generalizability of findings. All patients who were scheduled for a total hip or a total knee surgery at Concord Repatriation Hospital in Sydney, Australia, between the periods of March 2018 to January 2020 were eligible for this study.

3.2.3 Procedure

All participants were reviewed by the lead investigator (first author), and eligible participants were contacted by phone. After screening the participant and obtaining verbal consent to forward the study details, participants were mailed the participant information sheet, consent form, and the baseline questionnaire. Each participant was given a subject identification number to preserve anonymity. At the pre-admission clinic appointment (approximately 2-3 weeks before the surgery), the completed consent forms and data on the baseline questionnaires were collected by the investigator. Any questions or

clarifications regarding the study were answered, and assistance was provided with completing any unfinished questionnaires as needed. The pre-operative baseline physical assessment data were then collected as detailed below. Medical information such as past medical history and comorbidities were also collected from the medical records to check exclusion criteria.

After surgery, patients followed the standard post-operative care plan. Data were collected at discharge and at 6-week after surgery as part of the standard orthopaedic follow up at the hospital. At the 6-week assessment, all baseline assessments were repeated by the investigator.

3.2.4 Baseline

At the pre-operative clinical appointment, demographic information including age, gender, and postcode were collected as part of the baseline assessment. We included the ABS Socio-economic index for areas (SEIFA), the Index of Relative Socioeconomic Disadvantage (IRSD) specific to a patient's postal area (ABS 2016) was used.

Data from four health questionnaires were collected: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Bellamy et al. 1998), Pain Catastrophizing Score (PCS) (Sullivan, Bishop & Pivik 1995), Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith 1983), and a falls questionnaire. In addition, three physical assessments were performed at the pre-admission clinic, and included the Physiological Profile Assessment (PPA), the Timed up and Go Test (TUG), and the Choice Stepping Reaction Time Test (CSRT). Please see chapter 2 for detailed description of questionnaires and physical assessment measures.

3.2.5 Questionnaires

WOMAC. This is a validated scale designed to assess pain, stiffness, and physical function of patients with knee and hip osteoarthritis (Bellamy et al. 1998).

Pain Catastrophizing Scale. This is a widely used instrument that measures three components of pain catastrophizing: rumination, magnification, and helplessness (Osman et al 1997; Snaith 2003).

Hospital Anxiety and Depression Scale. This scale is regarded as a valid and reliable instrument for clinical and research use to identify anxiety and depression (Osman et al, 1997).

Falls reporting Participants self-reported the number of falls experienced during the 12 months prior to the baseline assessment. A fall was defined as the participant unexpectedly coming to rest on the floor without an external force (Lamb, Jorstad-Stein, Hauer & Becker 2005).

3.2.6 Physical Assessment

Physiological Profile Assessment (PPA). The PPA concerns a series of tests that take approximately 20-25 minutes to complete and assess falls risk through tests of vision, peripheral proprioception, muscle force, reaction time, and postural sway (Lord, Menz, & Tiedemann 2003).

Timed Up and Go Test (TUG). The TUG is a performance test that assesses a participant's functional mobility (Podsiadlo & Richardson 1991). The test requires the participant to stand up from a chair, walk 3 metres and return to a sitting position.

Choice Stepping Reaction Time (CSRT). This test measures body weight and balance transfers required to avoid a fall (Lord & Fitzpatrick 2001). The CSRT requires

participants to stand on a portable rubber mat and step quickly and accurately onto four targets for a total of 20 steps while being timed (Lord, 2001).

3.2.7 6-week follow-up

All baseline pre-operative measures (i.e., four health questionnaires and all physical assessments) were repeated at 6-week follow up. For falls reporting, two timeframes were investigated by self-reported number of falls: 1) Pre-operative falls, the number of falls in the period from baseline assessment to surgery and 2) Post-operative falls, detailing any falls from surgery up to 6- week post-surgery were recorded.

3.2.8 Statistical Analysis

Descriptive statistics (means, median, standard deviations, and ranges) were used to describe the study population at baseline and follow-up. We evaluated differences between completers (participants who completed the baseline and 6-week post-operative assessment) and non-completers (participants who did not complete the 6-week post-operative assessment) using a paired t-test.

We used paired t-tests to compare the falls risk, functional mobility, and psychological factors at baseline and 6-week follow-up. These results are presented as mean and standard deviation. For all analyses, we consider a difference of 20% clinically relevant and a p-value <0.05 (two-tailed) statistically significant. Data analysis was performed with IBM Statistical Package for Social Sciences (SPSS) version 26 (IBM Corporation, New York) for Windows.

To account for missing data, we used the worst-case simple imputation strategy (impute the maximum recorded score from the dataset) (Donders, Van der Heijden & Moons 2006).

3.3 RESULTS

3.3.1 Participants

A total of 174 patients were screened during the 2-year period (March 2018- January 2020) and 118 patients were eligible to participate in the study. Of these, 11 participants had their surgery cancelled due to medical reasons and 7 refused to participate therefore, 100 participants entered the study: 48 males and 52 females (Figure 1). Of the 100 participants at baseline, 32 failed to attend the follow up appointment at 6-week due to time and/or transport restraints.

3.3.2 Baseline Characteristics

First, we evaluated whether there are clinically relevant differences between the completers and non-completers (see table 4).

Table 4

Population characteristics at baseline

Characteristic	Baseline	Completers	Non-completers
Total number	100	68	32
Male, n (%)	48 (48%)	33 (49%)	15 (47%)
Age, (Mean ± SD)	66.9 (±9.9)	67.4 (±9.2)	66.9 (±9.9)
No comorbid health conditions	26 (26%)	12 (18%)	10 (31%)
Total knee replacements	67 (67%)	50 (74%)	17 (53%)
WOMAC (0 – 96; median IQR)	60 (51-72)	60 (25-75)	58 (44-68)
Catastrophizing (0 - 52; median IQR)	18 (7-35)	18 (5-35)	13.50 (9-35)
Anxiety (0 - 21; median IQR)	7 (4-11)	7 (5-11)	7 (3-13)
Depression (0 - 21; median IQR)	7 (4-9)	7 (4-9)	7 (3-11)
Falls, 1 or more previous 12 months	32 (32%)	25 (37%)	7 (22%)
Fall risk (PPA: -3 to +3)			
Low risk (-3 to 0)	14 (14%)	14 (21%)	4 (13%)
Mild to moderate risk (>0 to 2)	60 (60%)	21 (31%)	23 (72%)
High risk (>2 to 3)	26 (26%)	33 (49%)	5 (16%)
Functional mobility (TUG; median (sec); IQR)	14 (11-18)	14 (11-18)	14 (11-20)
Fall risk (CSRT (sec); median IQR)	47 (38-53)	48 (38-53)	46 (36-52)

Abbreviations: SD=standard deviation; IQR=Interquartile range; PCS=Pain Catastrophizing Scale; HADS=Hospital Anxiety and Depression Scale; PPA=Physiological Profile Assessment; CSRT=Choice Stepping Reaction Time Test; TUG=Timed Up and Go; WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index; sec=seconds

The patients who did not complete 6-week assessment (non-completers) overall had more comorbidities (13%), less often a knee replacement (i.e., more often a hip replacement) (-21%), had more often a mild to moderate fall risk (41%) less often a high fall risk (-

33%), and reported fewer falls (-15%) in the previous year than those who returned for follow up (completers).

Of the 68 participants, 56 had at least one or more comorbid medical conditions such as hypertension, hypercholesterolemia, diabetes, or other musculoskeletal conditions such as rheumatoid arthritis and gout; 50 had a knee replacement, and 18 had a hip replacement.

Overall, the scores on the health questionnaires show that at baseline, the completers had a low score for catastrophizing (<24), a low score on anxiety and depression (<11), but a relatively moderate score on the WOMAC, indicating more severe symptoms. From the physical assessment, responders had a mild to high fall risk on the PPA. For the TUG and the CSRT responders were also at higher risk for falls (i.e., TUG >13.5s and CRST >22s).

3.3.3 6-week follow up

Scores for the health questionnaires (WOMAC, PCS, and HADS) and the physical assessment are reported in Table 5.

Table 5

Differences between baseline and follow-up

Characteristic	Baseline (n=68)	6 weeks post-op	Difference
WOMAC (mean, SD)	59.81 (16.71)	42.95 (20.10)	16.93 (21.40) *
Catastrophizing (mean, SD)	20.44 (16.23)	10.3 (11.40)	10.25 (13.60) *
Anxiety (mean, SD)	7.61(4.40)	5.47 (4)	2.26 (3.74) *
Depression (mean, SD)	7 (3.80)	5.50 (3.80)	1.52 (4) *
Fall risk (PPA, mean, SD)	1.33 (1.52)	1.41 (1.52)	-0.05 (1.40)
Low risk (-3 to 0)	14 (21%)	11 (16%)	-5%
Mild to moderate risk (>0 to 2)	21 (31%)	34 (50%)	+19%
High risk (>2 to 3)	33 (49%)	23 (34%))	-13%
Function mobility (TUG, mean, SD)	16.73 (9.67)	16.12 (6.42)	0.50 (9.31)
Fall risk (CSRT; mean, SD)	46.21(10.38)	47.64 (13.53)	-1.42 (10.25)

Abbreviations: SD=Standard Deviation; PCS=Pain Catastrophizing Scale; HADS=Hospital Anxiety and Depression Scale; PPA=Physiological Profile Assessment; CSRT=Choice Stepping Reaction Time Test; TUG=Timed Up and Go; WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index

*: statistically significant difference at $p<.05$

Table 5 also reports the differences in psychological factors and physical assessment from pre and 6-week post-surgery. All scores on the health questionnaires decreased (indicating improved outcomes). Although the scores on all questionnaires showed a statistically significant improvement, the differences were not considered clinically relevant: WOMAC -17.6%; catastrophising -19.6%; anxiety: -10.5% and depression -7.1%. Of note, pain catastrophising reduced below the cut off 15, indicating that the level of catastrophising was no longer in the range of concern.

On the physical assessment measures, we found no differences between baseline and follow-up. The fall risk on the PPA shows a shift from high risk to moderate risk, although the overall score did not change. Although, falls risk assessed with the PPA and the CSRT test increased, this was not significant suggesting no change in falls risk at 6-week follow-up. In addition, there was no significant change in functional mobility as assessed with the TUG. Three participants could not complete the CSRT test due to pain; we imputed the maximum recorded CSRT score from the data set (Donders et al., 2006). A total of 3 participants reported a fall (one responder and two non-responders) pre-operatively, and five completers fell after surgery during the 6-week post- operative period

3.4 DISCUSSION

3.4.1 Main findings

We found that the number of falls and falls risk was unchanged from pre-surgery to 6-week post-surgery. In addition, psychological factors, which are known to influence post-operative outcomes, improved from baseline to 6-week post-surgery. Patients undergoing lower limb joint replacement also reported improved function, but we found no change in physical assessments of mobility.

3.4.2 Comparison with literature

From hospital admission to 6-weeks post-surgery, we found no significant change in the number of falls or falls risk based on the PPA, TUG, and CSRT test. Thus, using these outcome measures, falls and falls risk in the immediate post-operative period are unlikely to contribute to increased costs in people undergoing total hip or knee replacement. This finding is supported by a prospective study showing that patients undergoing joint replacement had reduced falls each quarter after surgery up to one-year post-operation

(Swinkles et al. 2009). Furthermore, in this study patients identified as "fallers" pre-operatively became non-fallers after surgery, suggesting that falls risk improves after surgery (Swinkles et al.2009). However, pre-operative falls have been shown to increase the risk of post-operative falls in this population (Levinger et al. 2017). Although we did not see a change in falls from pre- to post-operative follow-up, our time follow-up frame was shorter than other studies (i.e., 6-weeks vs 3months to 1 year).

Our results show that psychological factors such as pain catastrophizing, anxiety and depression improved from baseline to 6-weeks after surgery. These improvements can positively influence the outcomes after total joint replacement procedure. This is also reflected by our finding of improved self- reported WOMAC (pain, function, quality of life and Activities of daily living) measures post-surgery. Psychological symptoms negatively influence patient motivation and coping with illness (Duivenvoorden et al.2013). It has previously been found that around 40% patients with chronic OA had symptoms of anxiety and depression (Axford et al. 2010). Pre-operative mental health and pain catastrophizing can also negatively affect post-operative outcomes after TKR and THR (Vissers et al. 2012). We hypothesised that the pre-existing psychological functioning and falls risk would improve after surgery. Our findings are consistent with the hypothesis and found that anxiety, catastrophizing, and depression were all decreased significantly at 6-week post-surgery compared to baseline while the falls risk did not worsen.

Our patients showed improvement in their WOMAC reporting from baseline to 6-week post-surgery without any improvement in mobility measured by TUG. This could mean that the 6- week follow up is too soon to reflect mobility gains while psychological factors

did show some gain during this period. This is consistent with other studies that have shown improvements in function (Kennedy et al. 2006; Bruyere et al. 2012).

Unfortunately, our findings showed statistically significant, but non-clinically important, improvements on the health questionnaires. While this statistical improvement in psychological factors from baseline is encouraging, the lack of similar improvements in falls and falls risk indicate the importance of screening and managing falls at baseline and post-surgery to improve outcomes in patients who undergo these procedures.

3.4.3 Strength & limitations

We acknowledge some limitations to our study. Our sample size was smaller than anticipated because of many dropouts prior to completing the 6-week follow up due to patient related factors and some surgeries being cancelled due to health risks of the patients. Although we found statistically significant differences these did not reach meaningful clinical relevance. We acknowledge that improvement in psychological factors post-surgery could have other contributing factors that we did not measure (for example buying a house, getting married etc). Our study also has a short follow up period of 6-weeks which reduces the ability to assess differences in variables such as falls. It may also be the case that patients in this study, who were in their late 60s on average, took longer than 6 weeks to fully recover from their surgery. The follow up time point may have been too early to capture complete recovery in this sample, and future research should incorporate longer follow up periods.

3.5 CONCLUSION

We found an improvement in physical and psychological functioning following THR and TKR surgeries from baseline to 6-week post- surgery, but no differences on fall risk. Studying the trend in falls, psychological factors, and physical function during pre-operative to post-operative period gives us valuable information that will influence recovery of these procedures preferably with longer follow-up periods. Screening and managing psychological factors and falls may improve post-operative psychological and falls related impact in patients waiting for TKR and THR and improve the post-operative outcomes.

CHAPTER 4

4.0 CONCLUSION

4.1 Summary of the thesis

The purpose of the thesis was to examine if previous falls history, current falls risk and relevant psychological factors play a role in clinical outcomes for people undergoing total joint replacement surgery (TKR and THR). This chapter summarises the findings of the thesis through the observational cohort study that was conducted, the implications of the findings for clinicians and health management, and future directions for research.

Chapter 1 provided background on osteoarthritis and total joint replacement surgery (TKR and THR) and identified post-operative outcomes important to surgeons, health systems, and above all, patients. Demographic factors that are associated with and may impact post-operative outcomes include age (Shah et al. 2019; Wylde et al. 2007), socioeconomic status (Brennan et al. 2014; Brennan & Turrell 2012), gender (Fitzgerald et al. 2004; Holtzman, Saleh & Kane 2002), co-morbid health conditions (Robbins, Rastrogi & McLaughlin 2014; Shah et al. 2019), and obesity (Prohaska et al. 2017; Shah et al. 2019). Physical factors were also identified and included presence of pre-operative falls (Arden et al. 2006; Swinkles, Newman & Allain 2009), pre-operative functional status (Shah et al. 2019), chronic pain, and psychological factors such as pain catastrophizing, anxiety, and depression (Axford et al. 2010; Edwards et al. 2009; Sullivan et al. 2009).

This is the first study to examine the relationship between pre-operative falls history, falls risk, psychological factors and the post-operative outcomes of LOS, the need for additional rehabilitation and the need for community support services when patients are discharged from the hospital. The identification of this knowledge gap was the catalyst for this thesis, which aims to address the following questions: a) Is there an association

between previous falls, falls risk, and psychological factors such as pain catastrophizing, anxiety, and depression on post-operative outcomes such as LOS, additional rehabilitation and community support services on discharge; b) How pre-operative falls frequency, falls risk and psychological factors change from pre- to post-surgery?

4.2 Overview of the main findings

To answer the study questions, a prospective cohort study with six weeks follow-up was conducted. Chapter 2 confirmed that for patients undergoing TKR and THR, pain beliefs (pain catastrophizing) and mood (anxiety and depression), as well as the number of falls experienced and the risk of falling, were associated with a range of poorer outcomes including LOS, the need for additional rehabilitation and additional community support on discharge

This study reports that patients with pre-operative pain catastrophizing and depression have a significant positive association with longer LOS such that for each 10-point increase on the pain catastrophizing and depression scores there is a 0.5 to 1.5 day of additional acute hospital stay in these patients, respectively. This finding is important as it identifies psychological factors that could be addressed pre-operatively which may reduce LOS post-operatively. Buvanendran et al (2021) showed that Cognitive Behaviour Therapy (CBT) interventions delivered prior to surgery can reduce PCS scores post-surgically. A systematic review showed that peri-operative intervention targeting psychological distress for patients receiving TKR procedure have post-operative improvements in pain, function and quality of life measures (Sorel et al.2020). Our study results support the idea of such early screening and interventions for pain catastrophizing, depression, falls risk and function. Implementation of such a process will assist clinicians

and health managers to identify patients who are at high risk of poor post-operative hospital-based outcomes and provide effective intervention in order to improve outcomes. The second set of results from the study (presented in Chapter 3), confirmed that psychological factors such as pain catastrophizing, anxiety and depression improve from baseline to 6 weeks post-surgery. The number of falls did not show any change while the WOMAC functional scores improved from baseline to six weeks post-operatively indicating that total joint replacement procedures are effective in improving psychological factors and self-reported function by 6 weeks post-operation. It is likely that we did not identify any changes in the number of falls due to the short follow up period.

We acknowledge some limitations to our studies. In the first study we did not measure factors such as the social support network of the patients. Patients who had extensive support network through family and friends at home may not have needed the additional community support services provided by the health system. We did not measure the variations in surgical approach of different surgeons involved which may have influenced the outcomes. Hence, the study results may not be fully generalizable to the population. A large number of dropouts prior to completing 6-week follow up lead to a smaller sample than anticipated for our second study. The follow up time point may have been too early to capture complete recovery in this sample, and future research should incorporate longer follow up periods.

4.3 Implications and suggestions for future research

Previous fall history and the psychological functioning of patients are not screened routinely and do not form part of the basic admission protocols prior to joint replacement procedures in public hospitals in Australia. This thesis arose from the clinical observation of the primary investigator that patients who have a previous history of falls, pre-existing mental health difficulties, and have poor pre-operative function perform less well in terms of pain, function, and have longer hospital stays after TKR and THR procedures. The findings in this thesis confirmed the clinical observation that these associations are present and reinforce the importance of the role of patient factors beyond their primary diagnosis of OA on post-operative outcomes for patients undergoing joint replacement. Acting on this knowledge, identification of these pre-existing factors is essential to implement appropriate interventions to manage pain catastrophizing and depression prior to surgery, with the goal to reduce LOS and the need for additional rehabilitation services with ultimately improving patient centred care and reducing health costs.

The data presented in this thesis suggest that providing individual or group-based psychologist-lead interventional programs pre-operatively could be beneficial as this is likely to improve LOS. There is some evidence that pre-operative falls education and psychology education and improve pain and function after TKR (Clarke et al.2021; Sorel et al. 2020). In my study, pre-operative falls increased the chance of needing rehabilitation and pre-operative function showed a strong association with patients needing additional social support services on discharge. Again, identifying the pre-operative falls risk including balance and function and then targeting functional improvements through physiotherapy and occupational therapy based interventional programs may further assist

with reducing the additional rehabilitation and community support service needs, reducing health cost and improving patient centred care.

Overall, this thesis highlights the need for careful pre-operative assessment of patient mood and beliefs about pain and their falls and falls risk in patients awaiting joint replacement surgery in order to improve outcomes. It is ideal to screen for falls and psychological factors as soon as the patient is placed on the joint replacement waiting list. This will promote early identification and management options to provide psychological and functional interventions prior to these elective surgical procedures.

Further research is indicated to explore appropriate screening tools for psychological factors and falls, potential and feasible hospital or community based interventional programs including multidisciplinary approach to manage these factors pre-operatively. Research is also needed to provide information on when the optimal timeline for screening is and how long the interventions are needed for the best outcomes. A randomised control trial that identifies pre-operative falls risk and psychological health with targeted multidisciplinary intervention with a post-operative follow up on hospital based and patient-based outcomes is likely to provide promising information that will assist in improving pre-operative and post-operative outcomes after total joint replacement surgery.

4.4 Conclusion

This thesis has shown that falls, falls risk, and psychological factors are associated with hospital outcomes. The early identification and management of these factors may be

important in improving outcomes of patients having total joint replacement surgery, which includes both the pre-operative waiting period and post-operatively.

Appendices: Questionnaires and scales

Appendix A1: The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The Western Ontario and McMaster Universities Osteoarthritis Index

(WOMAC)

Name:_____ Date:_____

Instructions: Please rate the activities in each category according to the following scale of difficulty: 0 = None, 1 = Slight, 2 = Moderate, 3 = Very, 4 = Extremely

Circle **one number** for each activity

Pain	1. Walking	0 1 2 3 4
	2. Stair Climbing	0 1 2 3 4
	3. Nocturnal	0 1 2 3 4
	4. Rest	0 1 2 3 4
	5. Weight bearing	0 1 2 3 4
Stiffness	1. Morning stiffness	0 1 2 3 4
	2. Stiffness occurring later in the day	0 1 2 3 4
Physical Function	1. Descending stairs	0 1 2 3 4
	2. Ascending stairs	0 1 2 3 4
	3. Rising from sitting	0 1 2 3 4
	4. Standing	0 1 2 3 4
	5. Bending to floor	0 1 2 3 4
	6. Walking on flat surface	0 1 2 3 4
	7. Getting in / out of car	0 1 2 3 4
	8. Going shopping	0 1 2 3 4
	9. Putting on socks	0 1 2 3 4
	10. Lying in bed	0 1 2 3 4
	11. Taking off socks	0 1 2 3 4
	12. Rising from bed	0 1 2 3 4
	13. Getting in/out of bath	0 1 2 3 4
	14. Sitting	0 1 2 3 4
	15. Getting on/off toilet	0 1 2 3 4
	16. Heavy domestic duties	0 1 2 3 4
	17. Light domestic duties	0 1 2 3 4

Total Score: _____ / 96 = _____%

Comments / Interpretation (to be completed by therapist only):

Appendix A2: Pain Catastrophizing Scale (PCS)

0 – not at all **1** – to a slight degree **2** – to a moderate degree **3** – to a great degree **4** – all the time

When I'm in pain …

1. ☐ I worry all the time about whether the pain will end.
2. ☐ I feel I can't go on.
3. ☐ It's terrible and I think it's never going to get any better.
4. ☐ It's awful and I feel that it overwhelms me.
5. ☐ I feel I can't stand it anymore.
6. ☐ I become afraid that the pain will get worse.
7. ☐ I keep thinking of other painful events.
8. ☐ I anxiously want the pain to go away.
9. ☐ I can't seem to keep it out of my mind.
10. ☐ I keep thinking about how much it hurts.
11. ☐ I keep thinking about how badly I want the pain to stop.
12. ☐ There's nothing I can do to reduce the intensity of the pain.
13. ☐ I wonder whether something serious may happen.

…Total

Appendix A3: Hospital Anxiety and Depression Scale (HADS)

Hospital Anxiety and Depression Scale (HADS)

Tick the box beside the reply that is closest to how you have been feeling in the past week.
Don't take too long over you replies: your immediate is best.

D	A		D	A	
		I feel tense or 'wound up':			**I feel as if I am slowed down:**
	3	Most of the time	3		Nearly all the time
	2	A lot of the time	2		Very often
	1	From time to time, occasionally	1		Sometimes
	0	Not at all	0		Not at all
		I still enjoy the things I used to enjoy:			**I get a sort of frightened feeling like 'butterflies' in the stomach:**
0		Definitely as much		0	Not at all
1		Not quite so much		1	Occasionally
2		Only a little		2	Quite Often
3		Hardly at all		3	Very Often
		I get a sort of frightened feeling as if something awful is about to happen:			**I have lost interest in my appearance:**
	3	Very definitely and quite badly	3		Definitely
	2	Yes, but not too badly	2		I don't take as much care as I should
	1	A little, but it doesn't worry me	1		I may not take quite as much care
	0	Not at all	0		I take just as much care as ever
		I can laugh and see the funny side of things:			**I feel restless as I have to be on the move:**
0		As much as I always could		3	Very much indeed
1		Not quite so much now		2	Quite a lot
2		Definitely not so much now		1	Not very much
3		Not at all		0	Not at all
		Worrying thoughts go through my mind:			**I look forward with enjoyment to things:**
	3	A great deal of the time	0		As much as I ever did
	2	A lot of the time	1		Rather less than I used to
	1	From time to time, but not too often	2		Definitely less than I used to
	0	Only occasionally	3		Hardly at all
		I feel cheerful:			**I get sudden feelings of panic:**
3		Not at all		3	Very often indeed
2		Not often		2	Quite often
1		Sometimes		1	Not very often
0		Most of the time		0	Not at all
		I can sit at ease and feel relaxed:			**I can enjoy a good book or radio or TV program:**
	0	Definitely	0		Often
	1	Usually	1		Sometimes
	2	Not Often	2		Not often
	3	Not at all	3		Very seldom

Please check you have answered all the questions

Scoring:
Total score: Depression (D) _____ Anxiety (A) _____
0-7 = Normal
8-10 = Borderline abnormal (borderline case)
11-21 = Abnormal (case)

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