DISSERTATION

PAIN, FUNCTION AND HEALTH-RELATED QUALITY OF LIFE IN TOTAL KNEE ARTHROPLASTY

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Declaration

I, Mrs Helena Gertruida van de Wall, hereby declare that this dissertation titled:

Pain, function and health-related quality of life in total knee arthroplasty.

Submitted in the fulfilment of the degree, M.Sc. (Physiotherapy), is my independent work, except where other sources have been acknowledged.

I, Helena van de Wall also certify that this dissertation has not been submitted at this or any other faculty or institution.

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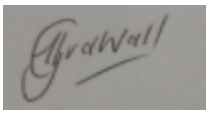
Signature: 

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Abstract

Introduction: Physiotherapists daily treat patients who undergo a total knee arthroplasty (TKA) and find that certain patients tend to function better during their rehabilitation than others. Although it is a successful procedure, some of the patients are not totally satisfied with the outcomes and develop chronic pain and limitations in activities of daily living (ADL).

Aim: The aim of the study was therefore to determine the pain intensity, functionality, and health-related quality of life (pre-operatively and post-operatively), in persons undergoing a total knee arthroplasty.

Methodology: A prospective cohort analytical study design was utilised. The cohort period was six weeks. Fifty (50) participants participated in this study. All participants were assessed after six weeks by completing several questionnaires and evaluations. Data were analysed by a biostatistician using descriptive statistics; namely, percentages and frequencies for categorical data and means and standard deviations or medians and percentiles for continuous data calculated per collection time point. The change between time points was calculated by means of 95% confidence intervals. Inferential analysis and significance testing was done.

Results: There were statistically significant improvements in oedema of the knee, knee extension, average pain experienced daily, pain relief with medication, enjoyment of life, relations with other people, normal work ability, walking ability, mood, total WOMAC (Western Ontario and McMaster Universities Arthritis Index) score and subdivisions and in the Hospital Anxiety and Depression Score (HADS - anxiety and depression).

Conclusion: The study describes the characteristics of the individuals who received an elective TKA in a private hospital in Bloemfontein. The importance of physiotherapy management pre-operatively and post-operatively is undeniable, as most of the patients experienced pain and decreased function that impacted their quality of life. Specific recommendations for further research have been put forward as well as clinical recommendations. This is to improve not only the outcomes of a TKA, but also to create awareness amongst physiotherapists regarding the challenges that individuals experience after a TKA and the importance of appropriate and relevant pre-rehabilitation and post-rehabilitation.

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List of abbreviations

ADL	Activities of daily living
AVIKA	Adding Value in Knee Arthroplasty
BMI	Body Mass Index
BPIsf	Brief Pain Inventory short form
EULAR	European League Against Rheumatism
HADS	Hospital Anxiety and Depression Scale
HRQoL	Health-related Quality of Life
KOOS	Knee injury and Osteoarthritis Outcome Score
OA	Osteoarthritis
PPP	Persistent Post-operative Pain
RA	Rheumatoid Arthritis
SES	Socio-Economic Status
SF 36	Short Form 36-item Health survey
TKA	Total Knee Arthroplasty
WHO	World Health Organization
WOMAC	Western Ontario and McMaster Universities Arthritis Index

1. Introduction

1.1 Introduction

Physiotherapists daily treat patients who undergo a total knee arthroplasty (TKA) and find that certain patients tend to function better during their rehabilitation than others. Some patients are inclined to get out of bed more efficiently than others; walk better (longer distances and with more ease) with a walking aid; deal better with their pain; and execute exercises more effectively. Patients also differ in their understanding of what their surgery entails; how the rehabilitation process is followed and how anxiety levels influence their perception of their recovery; and what is expected of them for the road ahead. It is acknowledged by the researcher that the choice of which orthopaedic surgeon, technique/expertise or prosthesis may play a role in the recovery process. The question arises: which factors can have an impact on the outcome of the TKA?

There is currently no clear indication as to why certain patients perform better than others after a TKA or why certain patients are more satisfied with the outcome after a TKA. The study would be significant in identifying the change pre-operatively and post-operatively not only in terms of function, but also in terms of Health-Related Quality of Life. This information would assist physiotherapists in adapting treatment protocols for patients undergoing a TKA.

Older patients, especially over 55 years, develop knee osteoarthritis (OA). The loss of function requires surgery and further rehabilitation is needed (Unver *et al*., 2014). Age is usually the main cause of primary OA, where joint diseases, injury or growth disorders result in secondary OA (Vuorenmaa *et al.*, 2008). Female gender, trauma to the knee, overweight patients, hereditary factors, excessive knee angle (Valgus, Varus), heavy physical work and inflammatory joint diseases are factors further affecting an individual to secondary OA (Vuorenmaa *et al.*, 2008).

The last decade showed a growing need for TKA procedures, making it the second-most prevalent orthopaedic surgical procedure performed by orthopaedic surgeons globally (Desmeules *et al.*, 2012). Petersen *et al*. (2015) agree with the finding of Desmeules *et al.* (2012), confirming the predicted increase in TKA, due to a rise in sedentary lifestyle choices and expected global growth in the elderly population. An orthopaedic surgeon in Johannesburg indicated that there is an estimate 8 000 to 10 000 TKA's performed in South Africa each year (*businesstech*, 2021).

According to So (2017), other factors for an increase in TKA can include the fact that our life expectancy keeps increasing and that a rise in obesity puts more load on weight-bearing joints (So, 2017). Positive patient experience/patient testimonials and an increased birth rate in certain decades are also mentioned on this platform as factors that could influence an increased need.

The researcher observed whilst managing individuals after a TKA that, although it is a successful procedure, some of the patients are not totally satisfied with the outcomes and develop chronic pain and limitations in activities of daily living (ADL). Numerous studies have investigated pain, function, psychological aspects, and co-morbidities after a TKA (Hassett *et al*., 2018; Razak *et al.,* 2016; Unver *et al*., 2014; Masselin-Dubbois *et al*., 2013; Sullivan *et al.,* 2011; Wylde *et al*., 2011; Singh *et al.,* 2010; Riebe *et al*., 2009), yet after an intensive literature search, the researcher was unable to identify studies exploring function, pain, psychological aspects and comorbidities or Health Related Quality of Life (HRQoL) of the person undergoing a TKA. HRQoL can be described as an individual's level of physical and mental health perceptions (e.g., mood, energy level) and their correlates - including health conditions and risks, social status, functional support, and socioeconomic status (*Centers for Disease Control and Prevention*, 2018).
The aim of the study was therefore to determine the pain intensity, functionality, and health-related quality of life (pre-operatively and post-operatively) in persons undergoing a total knee arthroplasty.

1.2 Background and nature of the problem

Pain relief, regaining mobility or being able to perform a specific activity of daily living or a sport activity represent some of the motivations for a patient to undergo a TKA (Cremeans-Smith *et al*., 2009). According to Cremeans-Smith *et al*. (2009), individuals who put forward different motives for undergoing surgery vary in their post-operative results. If an individual cites pain as the cause for undergoing a TKA, increased levels of pain will be reported during the early post-operative period. On the contrary, the individual who describes goals of being able to perform a specific activity or regain mobility as their motive will achieve greater range of motion during physiotherapy pre-operatively.

Linton and Vlaeyen (2000) suggested that goal orientation of a patient might influence their recovery post-operatively. The individual's motivation of electing to have a TKA should be

understood in relation to avoidance - and approach goals. The latter can be described as optimistic results that a patient is expecting (favourite activity e.g., gardening, golfing, etc.), while avoidance goals are negative associations (anxiety of actions associated with pain) that a patient is hoping to sidestep. The individuals who expressed avoidance goals showed more pre-operative pain in the study by Linton and Vlaeyen (2000).

Patient satisfaction has been reviewed by Kahlenberg *et al*. (2018) in a systematic review performed with the MEDLINE database, extracting certain data points. Most of the studies included showed an 80% patient satisfaction after a TKA, while only one out of five patients were dissatisfied after the surgery (Ali *et al*., 2017; Graham *et al*., 2015; Baker *et al*., 2013; Clement *et al*., 2013; Bourne *et al*., 2010). The authors strongly suggested that patient satisfaction be utilised as an outcome measure after arthroplasties. Thambiah *et al*. (2015) showed in an Asian study that up to 19 % of the patients were dissatisfied with their TKA, which is similar to the findings of Kahlenberg *et al*. (2018).

Identifying influences affecting the results of TKA and patients at danger of poor outcomes after surgery remains a challenge (Desmeules *et al*., 2013; Pinto *et al*., 2013; States *et al.,* 2004). The results of TKA are multifaceted and research studies have investigated peri-operative surgical complications, prosthetic-related factors, personal and psychosocial factors (Desmeules *et al.*, 2013). Other factors that could also influence outcomes include: female gender, low levels of educational attainment, low socio-economic status, older age, longer disease duration, increased body mass index (BMI), comorbidities (chronic diseases for example diabetes), depressive symptoms, pre-operative use of walking aids and low levels of social support (Desmeules *et al.*, 2013).

Pain - and more specifically persistent post-operative pain (PPP) - has been listed in numerous studies as one of the main outcomes after TKA affecting quality of life and is deemed a good predictor off patient dissatisfaction (Laubach *et al.,* 2020; Reichel *et al*., 2019; Rice *et al*., 2018; Lewis *et al*., 2015). The Rice *et al*., (2018) study showed that even after most of the patients' pain is relieved after a TKA, there is still between 10% and 34% of patients feeling moderate to severe PPP in the affected knee ≥3 months post-operatively.
Functional limitations and muscle impairments (m Quadriceps) restrict the TKA patient in executing daily functional activities such as stairclimbing and walking (Meier *et al.*, 2008). It has

been suggested in the study by Meier *et al*. (2008) that a combination of neuromuscular activation deficits and muscle atrophy contributes to residual strength impairments. The Meier *et al*. (2018) study emphasises that if chronic muscle impairments are not adequately addressed, it can limit long-term functional improvements after TKA. It is well established that a TKA decreases pain and improves self-reported function, but according to Thomas *et al*. (2012) m Quadriceps strength does not recover to the levels of healthy age-matched individuals - even years after surgery. M Quadriceps weakness leads to functional consequences for the individual and is associated with a decrease in balance (Moxley *et al*., 1999), gait speed (Brown *et al*., 1995) as well as stair climbing (Mizner *et al*., 2005) and difficulty rising from a chair (Skelton *et al*., 1994).

Pre-operative anxiety and/or depression is a significant predictor of dissatisfaction after TKA (Ali *et al.*, 2017; Duivenvoorden *et al.*, 2013). The researchers suggested that a psychological assessment and treatment (pre-operatively) might improve patient satisfaction. Poorer mental health status has been shown to be associated with poorer surgical treatment and decreased overall health-related quality of life (Perruccio *et al*., 2011; Clark *et al*., 2004; Sharma *et al*., 2003). Masselin-Dubois *et al*. (2013) stated that catastrophizing, anxiety and depression are mostly considered to be predictive of chronic post-operative pain. A study by Wood *et al*. (2016) agreed with the findings, indicating that poor self-perceived function and pre-operative pain in joint arthroplasty patients are indicators of depression, anxiety and catastrophizing.

The association between pain, comorbidities, quality of life and physical function following knee and hip arthroplasty were investigated by Peter *et al*. (2015). They pointed out that there is a broad range of comorbidities that needs to be looked at concerning the patients' health status after total hip arthroplasty and TKA. In the mentioned study, there was a correlation between worse pain, physical function and reduced quality of life with an increased number of comorbidities post-operatively. Hypertension and hearing impairments were found to have the highest incidence in this group. In this specific study, it was mentioned that there are two factors that had the highest incidence of all comorbidities in TKA patients. The impact of hearing loss leads to an impaired ADL for the patient and also decreased function (mentally and physically) (Dalton *et al*., 2003). Hypertension is a comorbidity that has been mentioned in numerous studies as a risk factor, as the condition influences wound healing after an arthroplasty and the patient is at a greater risk for infection after surgery (Ahmed et al., (2011). The data from the current study correlate with data found by Sullivan *et al*., (2011) stating that hypertension, tobacco use, and diabetes mellitus were some of the comorbidities that could affect TKR results.

Comorbidities that can influence TKA outcomes are hypertension, history of tobacco use, chronic obstructive pulmonary disease, osteoarthritis of other joints and diabetes (Sullivan *et al*., 2011). The conclusions of the latter study recommended that a pre-operative evaluation of psychological factors may contribute in identifying persons at risk of poor outcomes following TKA.

1.3 Significance of the study

This study may assist in improving the management of TKA patients at risk of poor results and in identifying these risk factors pre-operatively. The question was, “Can we paint a holistic picture of the TKA candidate pre-operatively that can assist in better recovery and outcomes?” The researcher aimed to address the gap in literature in order to potentially assist orthopaedic surgeons, physiotherapists and patients to be better prepared before surgery.

1.4 Aim and objectives

The aim of the study was to determine the pain intensity, functionality and health-related quality of life pre-operatively and post-operatively in persons undergoing a total knee arthroplasty.

The objectives of the study within the specific population were:

- To determine the individual’s pain intensity at baseline pre-operatively and six-weeks post-operatively using the Brief Pain Inventory (BPI).
- To determine the individual’s function pre-operatively and post-operatively using the WOMAC.
- To determine the individual’s active and passive knee range of motion using a goniometer at baseline pre-operatively and at six-week follow-up.
- To determine the BMI of the individual at baseline and at six-week follow-up.
- To determine the HRQoL (health-related quality of life of the individual) by utilising the SF-36 baseline pre-operatively and at six-week follow-up.
- To determine the perceived anxiety and depression of the individual by utilising the HADS pre-operatively and at six-week follow-up.
- To determine the associations between levels of pain experienced, functional ability, HRQoL and BMI.

1.5 Dissertation outline

The chapters of the dissertation:

Chapter 1 briefly summarises an introduction and background to the study, as well as the motivation for this study and frameworks the aim and the objectives. Chapter 2 presents a literature review. In Chapter 3, the methodology and method of the study are described in detail. The following two chapters present the data obtained during the study as well as a critical discussion of the findings of the study. Lastly, recommendations are provided.

2. Literature Overview

2.1 Introduction

TKA is regarded as a very successful procedure worldwide to correct deformities and improve pain and function of the knee (Witvrouw *et al.*, 2009). According to the American Academy of Orthopedic Surgeons (AAOS), 90% of people who had a TKA experience a significant reduction in pain; and in addition, the patients can stay active and return to activities (e.g., golf and walking) that were not always possible before the TKA. The AAOS also mention that a TKA knee still functions after 15 – 25 years (Tifford 2020), so adding to the argument that a TKA can be seen as a successful procedure for the patient - leading not only to better quality of life, but also ensuring less pain and better mobility.

TKA is a surgical procedure utilised to replace the weight-bearing surface, tibia and femur to alleviate pain and/or disability in an individual living with osteoarthritis or pain that limits their functional ability. A prosthetic (metal or plastic) is used to resurface the ends of the tibia and femur that form the knee joint, along with the patella.

The last decade showed that the growing need for this procedure made it the second-most prevalent orthopaedic surgical procedure performed (Desmeules *et al.*, 2012). The identification of influences affecting the results of TKA and patients at danger of poor results remains a challenge. The results of TKA are multifaceted and research looked at peri-operative surgical complications, prosthetic-related factors, personal and psychosocial factors (Desmeules *et al.*, 2013). Presently, there is a lack of information regarding TKAs in South Africa.

As introduction to the literature review, a concise overview of the anatomy and the biomechanics of the knee joint will be provided before the focus of the literature review will shift to the prevalence of total knee arthroplasties (TKA) and factors that impact on the success of a TKA. In addition, the role of physiotherapy in TKA will be described.

A literature search was performed by the researcher utilising the EBSCOHost platform and including the following databases: Academic Search Ultimate, Africa-Wide Information, CINAHL with Full Text, Health Source - Consumer Edition, Health Source: Nursing/Academic Edition, MEDLINE, SPORTDiscus with Full Text.

2.2 Anatomy of the knee joint

Knee joint anatomy involves looking at each different structure in and around the knee. The knee joint consists of the tibia, femur and patella. The knee is one of the largest synovial hinge joints. It consists of two joints: the tibiofemoral joint and the patellofemoral joint. The knee allows motion in one plane (flexion and extension). Because it is a synovial joint, it has a joint capsule that contains synovial fluid that lubricates and nourishes the joint for effective, smooth motion. There are several muscles (that control movement) and ligaments that support and stabilise the knee. The main muscles responsible for knee movement and strength are the m Quadriceps, m Hamstrings, the gluteal muscles, and the m Gastrocnemius and m Soleus. Ligamentous support is provided by the anterior and posterior cruciate ligaments as well as the medial and lateral collateral ligaments. Sometimes overlooked in the knee is the patella, the bursa that reduces friction between the bone and the soft tissue and the patellar tendon. Articular cartilage and menisci assist with shock absorption and gliding between bones (*knee-pain-explained*, 2021). Static stability of the knee joint is provided by menisci and ligaments, where dynamic stability is provided by tendons and muscles.

Figure 1: Anatomy of the knee

(*knee-pain-explained*, 2021).

2.3 Biomechanics of the knee joint

The knee joint is one of the main joints assisting with walking, stability and proprioception of the lower leg; it also acts as a shock absorber and assists with functional activities such as sitting and standing (*versusarthritis*, 2021).

The knee is a synovial hinge joint; and the two main movements of the knee joint are flexion and extension. The articular surfaces of the femur roll and glide over the tibial aspect. The tibia and patella act as one structure in relation to the femur with knee extension and flexion. The Quadriceps muscle group (m Rectus Femoris, m Vastus Lateralis, m Vastus Medialis and m Vastus Intermedius) functions as a lever to pull the patella superior, thus extending the knee (*Physiopedia*, 2021). A secondary movement of the knee is internal and external rotation of the tibia in relation to the femur, but this is only possible if the knee is in flexion. The hamstring muscle group (m Semimembranosus, m Semitendinosus and m Biceps Femoris) mainly acts to assist with flexion of the knee and provides stability of the joint line medially/laterally. The normal range of motion for extension is 0°and the normal range for flexion is 140°.

Knee arthrokinematics can be described in terms of closed- and open-chain movement. It is based on the guidelines of concavity and convexity (Moore *et al*., 2010). During a squat, the flexion movement that takes place at the knee joint is automatically accompanied by movements of the hip and the ankle – this is then classified as a closed-chain movement. Closed-chain exercises include multiple joints and multiple muscle groups all at once and are safer for the knee joint, as the forces involved are compressive in nature, stabilised the joint and assist in strengthening the joint. Open-chain exercises, in contrast, tend to isolate a single muscle group and joints. Open-chain exercises produce shear forces that place stress on the knee joint, more specifically the anterior cruciate ligament - which may result in an injury. An example of an open-chain exercise is knee extension exercises or m hamstring curls (*Kennedy 2018*).

After a brief description of the anatomy and the biomechanics of the knee, a discussion will now follow regarding osteoarthritis (which is one of the main causes leading to a total knee arthroplasty in individuals) as well as the risk factors for knee osteoarthritis (OA).

2.4 Osteoarthritis of the knee joint

Arthritis is an inflammatory condition affecting one or more joints and is caused by factors including injuries, infections and normal aging. Osteoarthritis in turn causes inflammation, breakdown and eventual loss of cartilage in joints (*MedicineNet*, 2021). This results in pain, swelling and stiffness of the joint and often leads to muscle strain (Arend, 1997). Pain is the symptom responsible for individuals seeking assistance from a health care professional and contributes to functional limitations and a decrease in the quality of life of the individual (Ayis and Dieppe, 2009; Dominick *et al*., 2004).

Osteoarthritis is one of the most common joint diseases worldwide in adults and the incidence increases with age. Intrinsic and extrinsic factors are responsible for the development of OA. Knee osteoarthritis is the most common type of osteoarthritis (Andrianakos *et al*., 2006).

Participating in sport, injury to the joint due to repetitive movements (especially kneeling and squatting), obesity and genetics all predispose athletes to the development of early onset OA (Blagojevic *et al*., 2010). Age, gender, overweight and especially obesity, previous knee injury and repetitive use of the knee joint, muscle weakness, bone density and joint laxity all play a role in the development of knee OA.

Mechanical forces placed on the joint is a significant cause of developing OA and is one of the most important modifiable risk factors as determined by BMI. Being a female, lower educational levels, obesity and weak muscles are all associated with symptomatic disease and lead to disability in the long term (Lementowski and Zelicof, 2008). Participation in impact, rotation and jumping sports increases the risk of injury - especially to the knee. (Logerstedt et al., 2022). Mechanical loading of a weight-bearing joint will influence the capacity of the local tissues (bone, cartilage, meniscus, ligament and tendon) and the adaptation of these structures on physiological level then take place (Logerstedt et al., 2022). Weight loss, modifications of specific ADLs and functional strengthening should be some of the factors being addressed by health care professionals after a TKA.

Osteoarthritis of the knee can be diagnosed by clinical features and patient history (Heidari, 2011). The American College of Rheumatology's criteria for the diagnosis of knee OA (using clinical examination and patient history), are (Heidari, 2011): pain in the knee with any three of the following factors included; morning stiffness for less than 30 minutes; above 50 years; bony

tenderness; no palpable warmth of the synovium; bony enlargements; and crepitus on active movements. Confirmation of OA may require radiography or MRI examinations.

Based on the European League Against Rheumatism (EULAR) diagnostic criteria, the occurrence of three symptoms (reduced function, persistent knee pain and limited morning stiffness) and three signs (bony enlargements, crepitus, and restricted movement) can correctly diagnose 99% of knee OA when all six symptoms and signs are present (Zhang *et al*., 2010).

Thus, looking at all the mechanical and other factors causing a load on the knee, care should also be taken to address some of these factors after an TKA; for example: weight loss, functional strengthening and modifications of specific ADLs.

2.5 Prevalence and incidence of knee OA

An estimated 654.1 million (95% CI, 565.6-745.6 million; aged ≥40 years) people worldwide had knee OA in 2020. The ratios of prevalence and incidence of knee OA in men and women are 1.39 (95% CI, 1.24-1.56; *P* <.00), and 1.69 (95% CI, 1.59-1.80; *P* <.00), respectively (Cui *et al*., 2020).

In Table 1 and 2 below, the global prevalence and incidence of knee OA are indicated.

Table 1 - Global prevalence of knee OA (Cui *et al*., 2020)

Age	Percentage	Confidence level	Confidence interval
Individuals aged 15 or over	16%	95%	14.3% - 17.8%
40 years and older	22.9%	95%	19.8% - 26.1%

Table 2 - Global incidence of knee OA (Cui *et al*., 2020)

Age	Person-years	Confidence level	Person-year
Individuals aged 20 or over	203 per 10 000	95%	106-331 per 10 000
40 years and older	22.9%	95%	19.8% - 26.1%

In a systematic review conducted by Usenbo *et al.* (2015), it was found that the prevalence of OA in South Africa was 55.1% in urban settings and ranged from 29.5% up to 82.7% in rural settings among adults over 65 years. The incidence of knee osteoarthritis was the highest in rural South Africa with 33.1%. The authors suggested that some of the reasons can be attributed to differences in occupation and lifestyle (Solomon et al., 1975). OA of the knee was seen more in women than in men; and there was a strong association between obesity and with older women (Solomon et al., 1975). The authors concluded that there is a paucity of prevalence data on arthritis in Africa and that more studies are needed to address the lack of data (Usenbo *et al*., 2015).

Statistics from the Global Burden of Disease studies (2010) has indicated that in Southern sub-Saharan Africa, the rates of knee OA can be described as in Table 3 below.

Table 3 – OA rates in Southern sub-Saharan Africa

	Percentage of age-standardized prevalence of OA	Confidence interval (CI) (95%)
Men	3.1%	2.1% to 4.5%
Women	5.2%	3.5% to 7.4%

The increase in prevalence can in part be attributed to an increasingly aged population, obesity and decreased physical activity (Cross *et al*., 2014; Ackermann *et al*., 2011).

2.6 Management and treatment of osteoarthritis

Management and treatment options for OA include non-pharmacological, pharmacological, alternative treatment options and surgery. The patient should be part of the planning of the programme to enhance adherence and self-management (Rangiah *et al*., 2020). A multidisciplinary/interprofessional and holistic approach to management of individuals living with

OA, including referrals to other health care professionals, will possibly improve the outcome of the individual and improve their quality of life.

Physiotherapy forms an integral part of the pre-rehabilitation and rehabilitation process of a TKA patient. A South African study by Saw et al. (2016) confirms the importance of physiotherapy and how it can assist with pain reduction and function for patients awaiting a TKA. Conservative management approaches need to be attempted first before surgery.

2.6.1 Non-pharmacological management

Important and key non-pharmalogical interventions are health education, land-based exercise programmes and losing weight (Rangiah *et al*., 2020). Losing weight will assist the individual, in decreases the load on the joint and so decreases the inflammatory process. Education is necessary for the individual to understand the diagnoses; to know what they can/cannot do; to avoid fear avoidance of activities; and to confirm that they can partake in low-impact exercise.

Physiotherapy treatment will include symptomatic relief (soft-tissue release, massage electrotherapy, strapping, dry needling), mobility and strengthening programmes, hydrotherapy and assisting gait using one crutch. The physiotherapist will focus on increased functionality, but also explain pain and the mechanisms thereof. It is important to emphasise pain education and communication. Pain education and communication are important for the patient to understand the healing process; know what to achieve in the rehabilitation process; avoid misunderstandings; and prevent chronic pain.

2.6.2 Pharmacological management

Paracetamol was popular for decreasing pain, but its popularity has decreased with research questioning the safety of using the medication compared to the minimal benefits. NSAIDS (both topical and oral, non-steroidal anti-inflammatory drugs) are utilised most often as the pharmacological intervention for OA. While all NSAIDS provide similar effects, individual sensitivities of individuals using the medicine may differ. It is advised by Sangiah *et al*. (2020) that the lowermost dose for the shortest period of time should be used to achieve a medical response and ensure the least risk for long-term use. According to McAlindon *et al*. (2017), comorbidities should be taken into account when prescribing NSAIDS for the treatment of OA, as

this could potentially cause peptic ulcers. Opioids provide some relief for joint pain, but carries a risk of abuse. According to Machado *et al*. (2015), opioids in general should be avoided, but Tramadol can be used in certain instances if indicated. During an acute flare up for short-term pain relief, intra-articular steroids are beneficial; however, repeated injections may lead to rapid cartilage loss and do not provide long-term benefits to the individual (Rangiah *et al*., 2020).

2.6.3 Alternative treatments

Other, alternative treatment options that did not report good outcomes compared to physiotherapy and surgery include Tai Chi, yoga, walking aids, medial and lateral wedged insoles, Valgus directing force brace, knee brace, pain patches, glucosamine and chondroitin (Krych *et al*., 2017; Rangiag *et al*., 2020).

2.6.4 Surgical treatment

Total knee arthroplasty (TKA) is generally accepted as the preferred choice of treatment for advanced knee OA in patients who have failed to respond to non-surgical management. TKA is normally considered when conservative treatment such as physiotherapy management has failed, especially in a lower-resource setting like South Africa.

There are four main types of knee arthroplasty; namely a total knee arthroplasty; uni-compartmental or partial knee arthroplasty (a joint surface on only one side, usually the medial side/surface, is replaced); patellofemoral arthroplasty; and revision knee arthroplasty (*versusarthritis*, 2021).

The most utilised approaches for the standard primary TKA procedure include the medial parapatellar, midvastus, and subvastus approaches (Varacallo *et al*., (2021). After a literature review performed by the researcher, the most preferred approach in South Africa is still unclear.

Different surgical methods/approaches, designs and fixations are used by Orthopaedic surgeons, depending on the patient presentation as well as the skill and preferred method of the orthopaedic surgeon (Parcells *et al*., 2016; *Medscape*, 2021).

The three basic types of TKA are:

- totally constrained
- semi-constrained
- unconstrained.

This could be described as the amount of constraint manufactured into an artificial joint and reflects the amount of stability that the prosthesis provides (Beard *et al*., 2020). Ground-breaking knee replacement surgery was performed in South Africa in 2019 by utilising a robotic arm in a private hospital in Johannesburg. This was the first time on the African continent that a TKA was performed utilising the state-of-the-art Mako robotic arm assisted surgery system. The advanced system for total knee replacement was already well established in Europe, the United States and the United Kingdom before it was used for the first time in South Africa (*businesstech*, 2021).

2.7 Prevalence and incidence of TKA

The prevalence of total knee replacements in the United States of America in 2010 was 1.52%. Prevalence was higher in females and increased with age, reaching 10.38% for TKA. The estimates calculate to 4.7 million individuals (3.0 million women and 1.7 million men) receiving TKAs (Kremers *et al*., 2014).

In Taiwan, 154 553 patients received TKAs between 1996 and 2010, with an increase of 202.56% over 15 years (Lin *et al*., 2018).

In a study by Rothbauer *et al*. (2018), the incidence of TKA in the German population in 2014, was 0.19 % for the knee and about 149 000 primary knee arthroplasties were documented in the same year. The researcher acknowledges that the utilization of TKA may vary by the country being studied, which may be due to differences in prevalence of OA, patient preferences, socioeconomic status and health care facilities.

In a Danish study by Bager *et al*. (2015), it was mentioned that in the United States more than 670 000 total knee arthroplasties were performed annually (Skou *et al.*, 2015). Also, in this study, it was found that the average annual prevalence of TKA reached 920 per 10 000 population and it was identified that there was an increase in two age groups: 50 – 54 and 90 – 94. In a systematic review and meta-analysis by Jacobs (*rheumatologyadvisor*, 2021), the authors found that 18 of the 88 studies were published between 2017 and 2020.

The American Joint Replacement Registry Annual Report in 2020 indicated that 1 897 050 primary and revised hip and knee arthroplasty procedures were performed between 2012 and 2019. The majority of the cases were total knee replacements (53.0%) (Springer *et al*., 2020).

Based on a review by Singh *et al*. (2019), it is predicted that the number of TKAs per year will increase by 110% in 2025 to 1 272 000 replacements/arthroplasties; by 182% in 2030 to 1 921 000 replacements; and by 401% in 2040 to 3 416 000 replacements. Replacements seem to occur more in females and in individuals aged 45 – 64 years of age and 65 – 84 years of age (Singh *et al*., 2019).

There is no national register for TKA in South Africa. Furthermore, no data regarding the prevalence and incidence of TKA in South Africa could be found by the researcher; however, an orthopaedic surgeon in Johannesburg indicated that there is an estimate 8 000 to 10 000 TKAs performed in South Africa every year (*businesstech*, 2021).

2.8 Factors influencing the outcomes of TKA

Risk factors for knee osteoarthritis identified by Heidari (2011) are body mass index, age, sex, difficulties in descending stairs, restricted-flexion range of motion, crepitus, palpable effusion, fixed-flexion deformity, traumatic onset and absence of whole leg pain (Peat *et al*., 2010). The risk factors will be discussed below. To be noted is that non-medical factors (personal, clinical or psychosocial) or variables can influence the outcomes of TKA. Factors mentioned influencing knee OA are age, race, gender, BMI, income, education and previous TKA (Creamens-Smith *et al*., 2009) and is incorporated in the following discussion.

2.8.1 Body mass index

As indicated earlier in the Introduction, TKA is a safe and effective procedure to alleviate pain and improve function in individuals living with knee joint pain. There is controversy in the available literature as to whether obesity and an increased BMI influence the outcome of the TKA. A meta-analysis conducted by Agarwal *et al.* (2021) indicated that obesity does not result in poorer post-operative outcomes following a TKA and should therefore not be considered by orthopaedic surgeons as a contra-indication to perform the surgery. Nevertheless, the authors concluded that future studies should be conducted including long-term follow-up randomised control trials to

establish if there are any potential differences in outcomes between normal BMI individuals and obese individuals that receive a TKA (Turki *et al*., 2015).

According to Evans *et al*. (2015), one in ten people in a cohort study in the United Kingdom will receive a TKA sometime during their lifetime. However, the authors indicated that TKA surgery has recently been restricted in the UK based on body mass index and the belief that a higher BMI may lead to poorer outcomes after surgery. The authors investigated associations between BMI, revision surgery, pain and function in the cohort followed between 2005 and 2016 and found that there does not seem to be any evidence to support the hypothesis that obese individuals would have worse outcomes after a TKA. The authors continued by stating that even if some patients do have an increased BMI and is possibly at risk for poorer outcomes compared to normal BMI individuals, the outcomes remain acceptable in terms of normal standards (Evans *et al*., 2021).

In a retrospective chart review of 204 patients in Saudi Arabia who underwent a TKA during 2007-2011, it was demonstrated by the authors that a higher body mass index value was not associated with longer hospital stay (Turki *et al*., 2015).

2.8.2 Age

Previous studies have indicated worse outcomes for younger (Elson and Brenkel, 2006; Singh *et al*., 2008) and older (Williams *et al*., 2013; Judge *et al*.,2012; Santaquida *et al*., 2008) patients undergoing a TKA. Age was an important predictor of post-operative resting pain according to Gagliese *et al*. (2008), Caumo *et al*. (2002) and Bisgaard *et al*. (2001). Rakel *et al*. (2013) have indicated that younger individuals undergoing a TKA with greater pre-operative discomfort and melancholy are most likely to have more pain after TKA. Other studies, in contrast, have indicated no difference in outcomes between age or a so-called U-shaped effect of age (Ethgen *et al.*, 2004; Jones *et al.,* 2001; Young *et al*., 1998). According to Edwards *et al*. (2018), a U-shaped effect can be explained as follows: when people at both ends of the range experience a worse outcome, compared to those in the middle of the spectrum. Middle-of-the-spectrum represents those individuals close to the mean age of the population investigated. The authors stated that the findings need to be interpreted with caution due to methodological differences and limitations including retrospective date, small sample sizes in some of the studies, and failure of the researcher to adjust for surgical and/or clinical confounding factors that could have influenced the results (Edwards *et al*., 2018).

A systematic review conducted by Lee *et al*. (2020) shows that patient-reported outcome measurements were good when the TKA was performed between the ages of 70 – 80 years; and according to the authors, the best patient-reported outcome measures is achievable around the age of 70 years. No significant differences were found in the mortality and revision rates between the ages of 70 and 80 years of age, but mortality seemed to increase with age. The authors therefore recommend that the optimal age for undergoing a TKA is in the early 70's year groups (Lee *et al*., 2020).

Age of participants should be considered as a predictor of the length of hospital stay, as elderly patients would benefit from special care to decrease the possibility of lengthier hospitalisation (Witvrouw *et al*., 2009).

2.8.3 Gender

The ratio female to male for TKR in Germany was 2:1 (Rothbauer *et al*., 2018), while a study conducted in Nigeria in a resource-constrained environment in 2016 indicated that the ratio female to male was 4.4 to 1 (Anyaehie and Eyichukwu, 2017). Total knee arthroplasty is available only in certain facilities in Nigeria and influenced by poverty and the availability of surgeons. Studies have demonstrated no difference in outcomes related to gender (Ritter *et al*., 2008; Jones *et al*., 2001) of the individual or worse outcomes in female patients (Nashi *et al*., 2015; Barrack *et al*., 2014; Santaquida *et al*., 2008).

A comparative study conducted by Ritter *et al*., (2008) investigating the clinical effect of gender on outcome of TKA found that the improvement after a TKA is similar in males and females.

Srikanth *et al*. (2005) found that females are at an increased risk for developing OA and that females are three times more likely that their counterparts to undergo a TKA at a more advanced stage of OA (Petterson *et al*., 2007; Srikanth *et al*., 2005). In addition, females experience more pain before and after the TKA (Ritter *et al*., 2008; Dalury *et al.*, 2009), but seem to have better outcomes than men with more improvements in function than males (MacDonald *et al*., 2008) Males seem to achieve a higher final level of function after a TKA than females (Lavernia *et al*., 2009).

2.8.4 Race

In the Hinman *et al*. (2020) study, differences in TKA outcome were observed, within universally insured populations in the United States. In this mentioned study, lower risk in some of the outcomes was detected for Asian and Hispanic patients, while higher risks of re-admission and revision was observed for black patients.

Ethnic and racial disparities in total joint arthroplasty (TJA) exist in all stages of arthroplasty care including postoperative outcomes, access to care and the utilization of care post arthroplasty (Chun *et al*., 2021). Factors seen in the Chun *et al*., (2021) study that limit patient access to TJA are lower socioeconomic status, increased patient comorbidities and insured/uninsured status. Minority patients are expected to need more intensive post-operative rehabilitation and non-home discharge placement. Cavanaugh *et al*., (2020) found that black women had meaningfully poorer physical function (PF) than white women during the years before and after TKA. There was also a strong correlation between poorer physical function post-operatively and poorer physical function pre-operatively. Goodman *et al*., (2016) found that ethnic/racial minority groups experience higher post-operative pain, lower satisfaction, poorer physical function and more residual joint stiffness after TKA. This latter study also concluded that the black population in the United States may benefit less from TKA than the white population as measured by pain, HRQoL, function and satisfaction. The authors recommended more studies evaluating the outcome of race and socioeconomic factors on TKA. No information regarding TKAs in South Africa could be found by the researcher.

2.8.5 Income

Skinner *et al*. (2006) found a slight association between socioeconomic status and the utilisation of total knee arthroplasty procedures in the United States. The researchers suggested that minority/lower income level groups are less likely to undergo TKA. The mentioned study also found no association between clinical evidence of knee osteoarthritis and socioeconomic status.

Barrak *et al*., (2014) reported that they could not find other socioeconomic factors that might be associated with satisfaction after a TKA. They concluded that patients with an income less than 25 000 USD (United States Dollar) were expected to be dissatisfied with the results and that they would probably have more functional limitations after their surgery than patients with higher

incomes. Contrarily, Singh *et al*. (2013) found in their study with data collected from the Mayo Joint Registry in the United Stated of America that patients with a lower income had better pain outcomes and more improvement in functionality than higher income patients.

Results from a study conducted by Feldman *et al*., (2015) on patients from the Adding Value in Knee Arthroplasty (AViKA) Observational Cohort or the AViKA Care Navigator Intervention Study in the United States of America indicated that individuals with higher individual- and area-level socioeconomic status (SES) had lower levels of pain and higher functional levels compared to patients with lower SES after a TKA (Feldman *et al.*, 2015). No information pertaining to income levels and outcomes after a TKA in South Africa could be found.

2.8.6 Education

Social factors are important determinants of health status, especially poverty. Goodman *et al*., (2016) found that pain after a TKA was significantly worse two years after the TKA in patients from resource-restricted environments and impoverished communities (Goodman *et al*., 2016; Goodman *et al*., 2016). Higher levels of education successfully completed have been associated with good health, and better outcomes (Rehkoph *et al*., 2006).

Goodman *et al*. (2018) conducted a study to determine the impact of community-level education, community-level poverty and individual level education on the Western Ontario and McMaster Universities Index (WOMAC), more specifically the pain and functional scores two years after a TKA. The WOMAC is a widely used self-administered health status measure used to assess pain, stiffness, and functional ability in patients with OA of the hip or knee joint. The WOMAC measures three different dimensions including pain, stiffness and function. A higher score on the WOMAC indicates worse functional limitations, pain and stiffness (*Shirley Ryan Ability Lab* , 2021).

A secondary objective of the Goodman *et al*., (2018) study was to determine if there is any interaction between community level poverty and individual level education as these factors seem to impact on reported health outcomes (Goodman *et al*., 2018). The results of the study indicate that individuals without college education from resource-restricted or impoverished communities obtained a WOMAC score of 10 points higher than individuals with some college education in the

same community after a TKA. However, education in more affluent communities did not influence the outcome of a TKA.

2.9 Function

Decreased function (can't take full weight on the leg and can't bend or extent the knee properly) or impairment in ADL (can't climb stairs or get up from a chair), still represent reasons for patients electing to undergo a TKA.

Orthopaedic surgeons use several tools to evaluate patients before and after surgery; for example, the KOOS (Knee injury and Osteoarthritis Outcome Score) or WOMAC to determine functionality. The WOMAC has been studied often; it is effective and consistent for measuring degrees pain and disability in patients having a TKA (Riddle *et al.,* 2012). The WOMAC has shown to have excellent validity, reliability, and face validity (*Shirley Ryan Ability Lab*, 2021) and has been confirmed by numerous researchers (Basaran *et al*., 2010; Pua *et al*., 2008; Greco *et al*., 2010; Whitehouse *et al*., 2003).

A six month follow-up study has been done on pain, fear of falling and stair-climbing ability in patients with knee OA before a TKA (Unver *et al*., 2014). Walking and stair climbing are critical functional activities identified by patients and clinicians before a TKA. In the Unver study (2014), the conclusion was that it would be rational to consider guiding the fear of falling as it would be potentially beneficial for preventing severe functional limitation in stair climbing for subsequent knee OA before surgery.

Patient-level improvements in pain and activities of daily living (ADL) following TKA can be utilised to inform patients before surgery of expected or possible results, founded on pre-operative status of the individual - which may assist the individual in setting realistic aims for outcomes after TKA (Singh and Lewallen, 2014).

Patients waiting for a TKA have reduced function and HRQoL (Desmeules *et al*., 2009). Desmeules *et al*. (2009) have indicated that poor functional outcomes could be used to promote and develop pre-operative rehabilitation programmes that could be beneficial to patients before a TKA. Pre-operative rehabilitation programmes could consist of interventions addressing weight

loss, decrease psychosomatic distress and therapeutic exercises to strengthen both knees (Desmeules *et al*., 2009).

Desmeules *et al*. (2012) found in their study that participants with a long waiting period before a TKA presented with specific functional limitations, impaired HRQoL and pain; and also presented with a negative effect on contralateral knee pain and HRQol, six months after surgery. A study conducted by Saw *et al*. (2016) on patients awaiting arthroplasty in public hospitals in SA indicates that a physiotherapist-led exercise and health-education intervention over a six-week period showed moderate effect size (ES) on pain severity at week 6: [p<0.01, ES=0.94,95%CI (0.45,1.41)] and moderate effects on pain interference at week 6: [p<0.001, ES=1.2, 95% CI (0.70,1.69)]. Fifty-three per cent of the participants in the study of Saw *et al*., (2016) indicated that the intervention improved their pain.

2.10 Pre-operative and post-operative pain

The main cause for patients seeking medical help and opting for a TKA is knee joint pain. Pain can be defined as an unpleasant sensation that is conveyed to the brain by sensory neurons. The distress signals warn the body to real or potential injury (Kumar and Elavarasi, 2016).

The most generally recognised and current definition of pain, recognised by the International Association for the Study of Pain (IASP), is "An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" (*Physio-pedia*, 2021a).

Despite new developments in the understanding of pain mechanisms and the introduction of different medication and new strategies in post-operative management, pain after TKA is still an unsolved problem (Grosu *et al*., 2014). Grosu *et al*. (2014) explain that pain affects the quality of life and rehabilitation of a significant proportion of patients undergoing TKA. The Oxford definition for quality of life can be described as: “The standard of health, comfort, and happiness experienced by an individual or group”. These researchers also mention that though numerous studies have confirmed improved pain, quality of life and function, up to 20% of patients who underwent TKA are in fact dissatisfied with their TKA.

As mentioned in the Introduction, patient satisfaction has been reviewed by Kahlenberg *et al*., (2018), where most of the studies included showed an 80% patient satisfaction after a TKA, while only one out of five patients were dissatisfied after the surgery (Ali *et al*., 2017; Graham *et al*., 2015; Baker *et al*., 2013; Clement *et al*., 2013; Bourne *et al*., 2010). The authors strongly suggested that patient satisfaction must be utilised as an outcome measure after arthroplasties. Thambiah *et al*. (2015) showed in an Asian study that up to 19% of the patients were dissatisfied with their TKA, which is similar to the findings of Kahlenberg *et al*. (2018).

Aa also mentioned in the Introduction, pain, and more specifically persistent post-operative pain (PPP) has been listed in numerous studies as one of the main outcomes after TKA, affecting quality of life and is deemed a good predictor of patient dissatisfaction (Laubach *et al.,* 2020; Reichel *et al*., 2019; Rice *et al*., 2018; Lewis *et al*., 2015). The Rice *et al*. (2018) study showed that even though most of the patients' pain is relieved after a TKA, there is still between 10% and 34% of patients feeling moderate to severe PPP in the affected knee ≥3 months post-operatively.

The source of discomfort after TKA is inflammatory, ischaemic, nociceptive, and neuropathic (Grosu *et al*., 2014; Smart *et al*.,2010). Smart *et al*. (2010) classified pain mechanisms as 'central' nociceptive, 'nociceptive' and 'peripheral neuropathic'. Pain is linked to the stimulation of neurons in response to ischemic, noxious chemical (inflammatory) and mechanical stimuli (Smart *et al*., 2010; Baron *et al*., 2010). Peripheral neuropathic pain is produced by a dysfunction in the peripheral nervous system (PNS), which leads to altered nerve functioning and responsiveness. Mechanisms include abnormal impulse generation, hyperexcitability and chemical, mechanical, and thermal sensitivity (Baron, 2000; Merskey *et al*., 1994). There could also be pathophysiological changes that may occur as a result of chronic pain (e.g., central sensitization). The importance of the Grosu *et al*. (2014) study is to acknowledge the physical healing process of the body and to differentiate between different pain mechanisms.

Managing pain, following TKA, allows patients to accomplish early mobilisation and assist them in participating in physiotherapy treatment and rehabilitation (Ramlall *et al*., 2014). The Ramlall (2014) study also suggest that this is important to both health care professionals and patients as there is an increasing interest in shortened length of hospital stay. The researcher hypothesises that this statement from Ramlell (2014) could draw more attention from medical aids and hospital managers. Undesirable results are persistent post-surgical pain (Lavand'homme *et al*., 2014),

stiffness, infection and functional limitations. Persistent discomfort can end in patient disappointment and its prevention embodies a challenge, as it is an indicator of health quality (Lavand'homme *et al.*, 2014). In the Lavand'homme study (2014), it is mentioned that if the pathophysiologic mechanisms of persistent pain are understood, preventative strategies can be planned and that underlying persistent pain will contribute to designing preventative strategies.

Lewis *et al*. (2015) concluded that catastrophizing, psychological health, pre-operative knee discomfort and pain at other areas are the strongest independent forecasters of persistent pain after TKA. The authors also discussed that women and younger age patients have been identified as risks for persistent post-operative pain. Pain catastrophizing was also identified as a significant predictor of chronic pain (≥ than 3 months) by a Canadian study (Burns *et al.*, 2015). Chronic pain is pain in one or more anatomical regions that persists or reoccurs for longer than three months, as stated earlier - and is associated with interference in activities of daily living or participating in social activities and causing emotional distress to the individual experiencing the pain. The aetiology for many forms of chronic pain is unknown (Treede *et al*., 2015).

According to Ramlall *et al.* (2014), managing pain in the TKA population can be challenging due to linguistic barriers. The TKA individual should be able to express him- or herself with regards to pain to ensure that their pain is managed before, during and after the TKA by the health care professional. The Ramlall *et al*. (2014) study could be used as motivation that the needs of patients who do not necessarily speak the language of the health care professional should be considered to ensure that the pain perceived by the patient is communicated in an effective manner to the health care professional, despite the language barrier.

High pre-operative pain intensity was an important forecaster of high pain intensity (stationary and during movement) after TKA - according to Rakel *et al.* (2013), who explored both physical and mental predictors of post-operative pain following TKA. The importance of this research was the focus on movement discomfort, which is most challenging for patients recovering after their surgery and, thus, an appropriate aim for improving patient care (Rakel *et al*., 2013). Age and positive depression screening were also prognostic indicators found in the study for post-operative resting pain (Rakel *et al*., 2013). The study by Rakel *et al*. (2013) recommends that approaches such as earlier surgery or adequate pain management before surgery may prevent the occurrence of intense postoperative pain. Reducing movement pain after the surgery could

also potentially reduce a patient's risk of poor recovery and/or preventing functional outcomes following surgery

Wade *et al*., (2012), provided confirmation that pain-related catastrophizing is a concept that is associated with pain intensity and is different from neuroticism. Catastrophizing seems to be more a state than a trait, especially after an intervention with efficient pain-relieving effects. The study also revealed that changes in catastrophizing in TKA patients over a period may reveal an improvement in quality of life associated with considerable decrease in pain. The same study stated that catastrophizing can be limited in patients living with pain by decreasing the pain intensity and changing the way people think about pain. Pre-operative pain catastrophizing that predicts pain outcome after TKA was investigated for six months in the United States by Riddle *et al*. (2010), after which the authors found that pain catastrophizing was the only reliable psychological factor responsible for a poor WOMAC pain outcome.

2.11 Comorbidities

Hypertension, osteoarthritis of other joints, diabetes mellitus, chronic obstructive pulmonary disease and history of tobacco use are some of the general comorbidities that can affect TKA results (Sullivan *et al*., 2011). Comorbidities might lead to complications after TKA; for example, deep venous thrombosis (DVT)/stroke/embolism, infection or delayed wound healing. (Sullivan *et al*., 2011). Sullivan *et al*. (2011) investigated the association between pain, comorbidities, quality of life and physical function following knee and hip arthroplasty. The authors point out that an extensive range of definite comorbidities needs to be considered with the patients' health status after total hip arthroplasty (THA) and TKA (Peter *et al*., 2015; Sullivan *et al*., 2011). Dizziness with falling, pain in other joints and vision impairments are factors that should be evaluated pre-operatively and treated to prevent poor outcomes. In the mentioned study, an increasing number of comorbidities was related to worse pain and physical function and reduced quality of life. Hypertension and hearing impairments were found to have had the highest incidence in this group. Sullivan *et al*. (2011) also concluded and recommended that pre-operative evaluation of psychological factors might assist in further identifying individuals at risk for poor outcomes following TKA.

2.12 Psychological factors (anxiety, depression, stress)

Depression and anxiety represent a large percentage of psychological challenges experienced by the general population. According to The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (*American Psyciatric Assosiation*, 2013), "generalised anxiety disorder 9GAD) is defined as a disorder characterised by excessive anxiety and worry that is not focused on a single trigger". According to Scott *et al*. (2015) and Riddle *et al*. (2010), the incidence of GAD (20.2%) and depression (22.5%) is higher in the orthopaedic TKA and total hip replacement population compared to the general population.

Anxiety, depression and catastrophizing are commonly considered to be predictive of chronic post-operative pain in all medical models (*Psyciatry Online*, 2021); Masselin-Dubois *et al*., 2013). A positive screening for depression pre-operatively remain a key factor of post-operative latent pain and post-operative movement pain (Rakel *et al*., 2013). Anxiety and depression, psychological distress and a predisposition to somatise have been recognised (pre- and post-operatively) as noteworthy predictors of poorer clinical results (Hirschmann *et al.*, 2013).

According to Gandhi *et al*. (2015), poor psychological status has consistently been revealed to be related to reduced overall HRQoL and to poorer outcomes of medical and/or surgical treatment. Sullivan *et al*., (2011) also concluded and recommended that pre-surgical evaluation of psychological factors might assist to identify individuals at risk for poor outcomes following TKA. Gandhi *et al*. (2015) report that pain is an indicator in chronic physical conditions not to be ignored, as it might increase rates of depression. They also state that a better understanding of influences that contribute to depression in patients with OA and identifying possible factors that could be changed to decrease the possibility of depression might assist in developing tailor-made treatment strategies that will positively influence the outcome of patients.

Patients with emotional distress had markedly poorer pre-operative pain and function in comparison to those patients who were not distressed (Lingard and Riddle, 2007). The latter study's purpose was to measure the independent influence of pre-operative psychological distress using the WOMAC pain and function scores on three separate time frames, after a TKA. Also discussed in the Lingard study, was that the psychological health of patients with pre-operative distress noticeably improved following surgery.

Riddle, *et al*. (2010) investigated the psychological aspects that predict clinical outcomes in patients after undergoing a TKA. The authors found that with pain catastrophizing, the risk for poor results increased in patients and that patients who underwent pain coping skills training pre-operatively reported a significant decrease in pain severity and catastrophizing and noted progress in function compared to the usual cohort two months after surgery (Riddle *et al.,* 2010). The findings provided evidence that the treatment may be effective for decreasing pain, catastrophizing and disability in patients with increased catastrophizing before surgery. Contradictory to the Riddle *et al*. (2010) study, pain catastrophizing and anxiety were not forecasters of post-operative pain as hypothesised by Rakel *et.al*, (2013). It has been proposed by Riddle *et al*. (2011) that catastrophizing might also lead to social reactions (e.g., increases in care from a worried partner) that may amplify the patient's focus on and feelings about pain.

Patients with a high score on the pain catastrophizing measure before surgery also had a longer hospital stay afterwards and would be likely to avoid movements and physical activities after surgery. Subsequently, this behaviour might influence progress in functionality (Witvrouw *et al*., 2009). A Cochrane systematic review conducted by Scranton (2001) showed that giving TKA patients pre-operative health education may result in improved recovery and decrease pre-operative anxiety.

Pinto, *et al*. (2013) recognised that mental factors in their study influenced post-surgical pain that is modifiable and can be changed through suitable pre-surgical psychological interventions. Brief cognitive-behavioural intervention methods (such as brief relaxation, imagery and positive coping self-statements) and providing information to the patient represent the gold standard to address pre-operative anxiety (Pinto *et al*., 2013). Patients living with or experiencing pain can also benefit from interventions (such as brief relaxation or imagery) to increase their optimism.

2.13 Role of physiotherapy before and after a total knee arthroplasty

The importance of physiotherapy in the prehabilitation and rehabilitation of any orthopaedic patient - but especially in TKA - is discussed in the following paragraphs. Physiotherapy can assist in improving range of motion, flexibility and increased strength both pre- and post-operatively.

The Saw *et al*. (2016) study confirmed how physiotherapy could assist in pain and function for patients waiting for a TKA. Physiotherapy is an integral part of the rehabilitation process pre- and post-operatively TKA.

2.13.1 Pre-operative physiotherapy

Pre-operative physiotherapy (also called prehabilitation, and which includes predominantly exercises) has the potential to improve post-operative outcomes in patients undergoing a TKA. Both the psychological and physiological outcomes may be changed with prehabilitation (*lermagazine*, 2021).

Several studies (Kwok *et al*., 2015; Ackerman *et al*., 2004; Gocen *et al*., 2004) have shown that there is a slight indication that pre-operative physiotherapy brings about substantial improvements in patient lower limb strength, outcome scores, pain, hospital length of stay and range of movement following total knee arthroplasty. The general value of the studies was moderate to poor, generally due to the small sample sizes.

The study of Edwards *et al*. (2017) captures the success of pre-operative classes for elective joint replacement patients. Literature reveals that education is a key component in decreasing anxiety; more realistic expectations and understanding of the surgery; and better post-operative pain control (Tait *et al*., 2015; Edwards *et al*., 2015). This can clinically lead to lower readmission, decreased hospital stay, lower costs and higher home discharge. Chen *et al*. (2014) agrees with the latter study, stating that pre-operative health-education intervention reduced the level of post-operative pain, increased patient compliance with rehabilitative exercises and enhanced functional recovery.

A study conducted by Swank *et al*. (2011) provided prehabilitation before TKA and found that prehabilitation increased the strength and function in older adults with severe OA. A single exercise session during the study included a five-minute warmup consisting of walking followed by nine lower body resistance training exercises that included hip flexion and extension exercises, squats, hip abduction and adduction exercises, knee flexion and extension exercises and ankle plantar and dorsi-flexion exercises. All the exercises were performed with Thera-Bands with an intensity to cause moderate fatigue. After the resistance exercises, participants completed a series of forward and lateral step exercises and concluded with a cool-down of light static muscle stretches and lastly 5 minutes of walking. The results of the study indicated that a four-to-eight-

week prehabilitation programme was effective in increasing muscle strength and improved function for individuals with severe OA and before a TKA (Swank *et al*.,2011).

Post-surgical therapy exercises may be provided to the patient before surgery, so that patients may achieve the appropriate exercises more efficiently directly after TKA surgery (*Physio-pedia*, 2021a)**.** A pre-operative exercise management plan may also be used to improve the functional status of patients to progress post-operative recovery. Pre-operative training plans should emphasize on functional lower limb exercises, postural control and strengthening exercises for bilateral lower extremities (Huber *et al*., 2013).

Gränicher *et al*. (2020) found that pre-operative rehabilitation improved the level of physical action before and after TKA and led to a clinically relevant gain in terms of the Tegner Activity Scale (TAS). The TAS offers a consistent system for defining the level of activity prior to injury and post injury. It can be documented on a numerical scale (Gränicher *et al*., 2020). The study of Gränicher *et al*., (2020) included physiotherapy training sessions consisting of five to nine sessions three to four weeks before the TKA and included 10-45 minutes endurance training on either a bicycle, pedal trainer or treadmill (this was patient dependent) with light to moderate intensity; the activity should not have elicited any pain. Proprioceptive Neuromusculoskeletal Facilitation (PNF) techniques for m Quadriceps and m Hamstring, specifically contract-relax-antagonist-contract (Gabriel *et al*., 2006; Sharman *et al*., 2006); patient education as well as individual interventions, when indicated, which included strengthening exercises (Husby *et al*., 2018), sensori-motor training (Dorma *et al*., 2018; Moutzouri *et al*., 2018; Wodowski *et al*., 2016) and or electromyostimulation training (Gondin *et al*., 2004) can be used.

A United Kingdom based, modified Delphi study was conducted by Anderson *et al*. (2021) and consensus was reached regarding the inclusion of TKA education and rehabilitation. The most important educational topics to be included were: purpose of pre-operative rehabilitation; patient involvement in their own management; making home preparations; arranging social support; what to expect during the hospital stay; risks of TKA surgery and how to minimise these; issues that may arise after TKA surgery (causing no alarm); pain expectations; what to expect following discharge; recovery expectations; pain management; and rehabilitation following TKA surgery. The highest rating by the panel was achieved indicating that physiotherapist should deliver the information, and that patients should be provided an opportunity for questions to be addressed. Numerous exercises were included in the list during the Delphi study, but the highest rating of inclusion was indicated for leg strengthening exercises and leg flexibility exercises.

In a South African based study, Saw *et al*. (2016) confirmed that physiotherapy could assist in decreasing pain and improving function in patients waiting for a TKA. Physiotherapy is an integral part of the rehabilitation process pre- and post-operatively TKA.

2.13.2 Post-operative physiotherapy

Rehabilitation provided by physiotherapists is widely used and promoted after total knee arthroplasties. However, the rehabilitation provided varies in content and duration. A systematic review conducted by Artz *et al*. (2015) found that there was no difference between the outcomes achieved with outpatient physiotherapy exercises compared to home exercises in physical function or pain outcomes. Range of knee flexion seemed to improve in the short term with home exercises compared to outpatient physiotherapy exercises. There were also no differences in the outcome when comparing exercises with hydrotherapy or when additional balancing exercise or cycling exercises were included in the rehabilitation programme. To be noted is that all the evaluation studies included in the review were under-powered (Artz *et al*., 2015).

A survey was conducted Artz *et al*. (2015) on physiotherapy exercises after a TKA in England and Wales by to determine what physiotherapy programmes are followed after discharge in high-volume orthopaedic centres. Group physiotherapy sessions in the high-volume orthopaedic centres included functional exercises, strengthening, stretching, task-related exercises and cardiovascular exercises. Individualised exercises and one-on-one sessions were also provided if deemed necessary. The one-on-one sessions included progression of gait re-education and further physiotherapy management was provided depending on the individual patient's needs. The treatment routinely provided during the one-on-one sessions included functional exercises, specific knee joint exercises and advice. No specific details were provided by the authors. Manual therapy was used for restricted knee range of motion. Electrotherapy or acupuncture was not indicated as a routine treatment by any of the centres. One centre indicated that patients living with chronic pain were referred to a pain management team (Artz *et al*., 2015).

Usual physiotherapy care at one centre following a TKA consisted of providing the patient with a knee replacement booklet given to patients during the pre-operative education class. The information contained in the booklet includes information regarding discharge planning; the pre-operative period; the day of the surgery; early and later stage post-operative exercise; how to

perform functional activities; and returning to work and hobbies after discharge. In addition, information is provided regarding precautions, potential problems and expectations after the TKA. Patients are advised by the physiotherapists to continue with the exercises in the booklet five times a day at home (Artz *et al*.,2015).

Certain centres utilised physiotherapy exercise classes that started six weeks after the TKA and lasted for six weeks. The duration of each class was 60 minutes and included 14 four-minute task-related exercise stations. The stations included the following exercises: range of motion exercises, m Quadriceps and m Hamstring strengthening exercises and muscle stretches; practicing getting in and out of the bed; balance exercises including single-leg stance and wobble board; treadmill walking at different speeds and squatting (Artz *et al*., 2015).

Post-operative procedures for assessment and management are recommended for patients who had a primary TKA, and the surgeon's instructions should always be followed - according to a physiotherapy website. The same website indicates that the use of range of motion, cryotherapy, strengthening exercises and gait training are characteristically introduced, and a home-exercise programme is given before discharge from hospital (*Physio-pedia*, 2021).

2.14 Health-related Quality of Life

Health-related quality of life (HRQoL) is a multi-dimensional concept that includes mental, physical, social and emotional functioning domains (*Healthypeople.gov*, 2020).

The World Health Organisation (WHO) defines quality of life as an individual's awareness of themselves in the world concerning their culture and value systems, in relation to their concerns, goals, standards and expectations (*World Health Organization*, 2006).

The measurement of health-related quality of life (HRQoL) has increasingly become important in determining the outcomes of interventions. Measurement of health-related quality of life (HRQOL) in individuals living with osteoarthritis (OA) assists the health care professional in determining and understanding the impact of the condition from the perspective of the individual and therefore assists in providing a more person-centred approach to the management of the condition (Zakaria *et al*., 2009). A cross-sectional study was conducted on patients with symptomatic OA of the knee attending two health clinics in Hulu Langat, Malaysia during 2003 and 2004. The results of the

study indicate that patients with OA of the knee attending primary care had relatively poor quality of life - especially regarding the physical components and that the impact was less observed in the mental components. The researchers concluded that similarities and difference in results of different studies investigating HRQoL of individuals living with knee OA could be attributed to many factors, including using different measuring instruments to determine HRQoL, selection of study participants as well as sample size - and not to be forgotten, inherent cultural differences that exist between countries (Zakaria *et al*., 2009).

2.15 Patient satisfaction

Patient needs and expectations for support are shaped both pre- and post-operatively (Goldsmith *et al.*, 2017). The study of Goldsmith *et al*. (2017) primarily considered support, or the provision of assistance, suggesting that support was insufficient when the patient's expectation of support was not met. Corroborating the findings of the above-mentioned study, Halawi *et al*., (2015) found that patient expectation was the most important predictor among all the variables (Halawi *et al.*, 2015).

Numerous studies have investigated pain, function, psychological aspects, and co-morbidities after a TKA (Hassett *et al*., 2018; Razak *et al.,*2016; Unver *et al*., 2014; Masselin-Dubbois *et al*., 2013; Sullivan *et al.,* 2011; Wylde *et al*., 2011; Singh *et al.,* 2010; Riebe *et al*., 2009) and found that patients still reported significant dissatisfaction post-operatively, specifically related to functional limitations and decreased quality of life (Ditton *et al.,* 2020).

As mentioned previously, patient satisfaction has been reviewed by numerous researchers, which showed dissatisfaction after a TKA and the suggestion was therefore made that that patient satisfaction must be utilised as an outcome measure after arthroplasties (Kahlenberg *et al*., (2018); Ali *et al*., 2017; Graham *et al*., 2015, Baker *et al*., 2013; Clement *et al*., 2013, Bourne *et al*., 2010).

Identifying influences affecting the results of TKA and patients at danger of poor outcomes after surgery remains a challenge (Desmeules *et al*., 2013; Pinto *et al*., 2013; States *et al.,* 2004). The results of TKA are multifaceted and research studies have investigated peri-operative surgical complications, prosthetic-related factors, personal and psychosocial factors (Desmeules *et al.*, 2013). Other factors that could also influence outcomes include: female gender, low levels of

educational attainment, low socio-economic status, older age, longer disease duration, increased body mass index (BMI), comorbidities (chronic diseases for example diabetes), depressive symptoms, pre-operative use of walking aids and low levels of social support (Desmeules *et al.*, 2013), as previously discussed in the literature overview.

In the next chapter, the researcher discusses the method of the research study and the procedure that was followed.

3. Methodology

3.1 Introduction

Physiotherapists treat TKA patients daily. Why do certain patients do better than the rest of their peers?

The information collected in the current study may be utilised to identify the limitations experienced by a patient before and after a TKA and to clarify which factors can influence the outcomes of a TKA. The results can be used to determine if specific care should be given to certain components or activities (ADL) pre-operatively. If indicated by the results, possible recommendations can be made to prospective TKA patients to increase quality of rehabilitation/after care. The aim was to include at least 50 patients within the scheduled six months period, also the scientific value of the study may assist to improve the management of TKA patients at risk of poor results and identify these risk factors pre-operatively.

3.2 Aim and objectives

The aim of the study was to determine the pain intensity, functionality and health-related quality of life pre-operatively and post-operatively in persons undergoing a total knee arthroplasty.

The objectives of the study within the specific population were:

- To determine the individual's pain intensity at baseline pre-operatively and six-weeks post-operatively using the Brief Pain Inventory (BPI).
- To determine the individual's function pre-operatively and post-operatively using the WOMAC.
- To determine the individual's active and passive knee range of motion using a goniometer at baseline pre-operatively and at six-week follow-up.
- To determine the BMI of the individual at baseline and at six-week follow-up.
- To determine the health-related quality of life of the individual by utilising the SF-36 baseline pre-operatively and at six-week follow-up.
- To determine the perceived anxiety and depression of the individual by utilising the HADS pre-operatively and at six-week follow-up.

- To determine the associations between levels of pain experienced, functional ability, HRQoL and BMI.

3.3 Research design

A prospective cohort analytical study design was utilised. The investigative period per patient was six weeks.

3.4 Study population

The study population consisted of all individuals undergoing an elective (TKA) performed by four orthopaedic surgeons at a private hospital in Bloemfontein, South Africa, who provided written informed consent to take part in the study.

3.5 Recruitment procedure

Participants were recruited from 01 March 2019 until 30 April 2019, if they were scheduled for a TKA surgery performed by either one of the four orthopaedic surgeons and indicated their willingness to support the researcher in the study. The post-operative period was conducted from 01 May 2019 until 31 July 2019. The researcher held an information session with the four orthopaedic surgeons and the physiotherapists who usually manage the specific orthopaedic surgeons' patients. They were informed about the aim and objectives of the study as part of the recruitment process.

It is standard procedure that physiotherapists evaluate patients pre-operatively as part of the pre-operative preparation for arthroplasties. The orthopaedic surgeons indicated their willingness to assist the researcher in the study and were requested by the researcher to consider referring their patients during the duration of the study to the researcher for evaluation. The orthopaedic surgeons provided eligible patients with a consent form, which provided the details of the researcher to be contacted by the patient if they were willing to participate in the study. In addition, the researcher also requested that the potential participant met with the researcher before the

six-weeks follow-up consultation with the orthopaedic surgeon to obtain the final data in the data collection process.

3.6 Study sample

Convenience sampling was utilised due to the limited population size of the possible study participant. All participants adhering to the inclusion criteria, and who were scheduled for a TKA with the four orthopaedic surgeons, and who provided written informed consent were approached by the researcher to participate in the study.

An average of 300 TKAs (elective and trauma) were performed during 2015 and 2016 during the development of the study at the private hospital in Bloemfontein where the research study took place. This information was utilised to inform the sample size of the study.

Table 1 – Total knee arthroplasty numbers for MEDICLINIC Bloemfontein

Year	**Total TKAs**
2015 and 2016	300
2017	340
2018	315
2019	372
2020	198

3.7 Sample size

The aim was to include at least 50 patients within the scheduled six months' period, also accommodating 15% loss of follow-up. The study would continue until a total of 50 participants had been included in the study. The researcher decided on 50 participants due to the time frame set out for data collection and the time it would take the researcher to evaluate and follow up

participants for the purpose of the study. The pre-operative evaluation included 41 participants that met the inclusion criteria and 31 participants for the post-operative evaluation. Some of the reasons for the drop out (pre-operatively) of patients were that some of the participants did not meet the age and BMI criteria. Three patients did not receive surgery after the researcher's evaluation, due to medical reasons (blood pressure, urinary tract infection and skin lesions). Post-operatively, the main reason for drop out was that the patient, especially if they lived outside Bloemfontein and the Free State, did not attend the follow-up appointment with the orthopaedic surgeon on the assigned time and date.

3.8 Participation Criteria

3.8.1 Inclusion criteria:

- Able to read and write English to complete and understand the questionnaires.
- First-time elective TKA on the specific knee
- Scheduled for a TKA by the designated orthopaedic surgeons at the private hospital in Bloemfontein.
- Age range between 40 and 85 years.
- Male or female gender.
- BMI range between 17 and 40.
- The individual needed to be ambulatory and able to walk with or without a walking aid.
- The individual had to be able to type an answer on a laptop with the assistance of the researcher.
- Must be willing to attend the scheduled follow-up appointment with the researcher on the six-week follow-up.

3.8.2 Exclusion criteria:

- If the individual was not able to perform ADLs due to a known severe cardiac condition.
- Neurodegenerative diseases, including Alzheimer's' or Parkinson's disease.
- If the individual was not able to perform independent ADLs due to muscle dystrophies.
- Mental disorders that had the potential to interfere with the ability to complete the questionnaires.

- Trauma patients; for example, fractures.
- Previous stroke patients or brain injuries where neurological deficits were clearly observed.
- Amputation patients where one of the two upper extremities or lower extremities were affected.
- Autoimmune diseases, including Multiple sclerosis and Amyotrophic lateral sclerosis (ALS).
- Individuals who indicated during recruitment that they would not be able to attend the six-week follow-up.

3.9 Measurement tools

The following measurement tools and outcome measures were utilised in the study to achieve the objectives as set out in the study.

A demographic, pre-operative and post-operative evaluation was completed. The prevalence of pain intensity, impairment of function and health-related quality of life was determined using various questionnaires. Four standardised questionnaires, the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC), Brief Pain Inventory Short Form (BPIsf), Hospital Anxiety and Depression Scale (HADS) and Short Form 36-Items Health Survey (SF-36) were utilised by the researcher. The questionnaires were made available only in English to participants, as the official language of communication in the private hospital is English.

3.9.1. The Western Ontario and McMaster Universities Osteoarthritis Index

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) has been studied extensively and its measures have been shown to be consistent and effective for measuring the degree of both pain and disability in patients undergoing TKA (Riddle *et al.,* 2012).

The WOMAC has been shown to have excellent validity, reliability and face validity (*Shirley Ryan Ability Lab* 2021). This has been confirmed by numerous researchers (Basaran *et al*., 2010; Greco *et al*., 2010; Pua *et al*., 2008; Whitehouse *et al*., 2003).

The WOMAC is a generally used, listed set of standardized questionnaires used by health professionals.

A universal description of the WOMAC is to determine stiffness, physical function and pain in patients with knee and/or hip osteoarthritis (OA).

The WOMAC contains 24 objects that separate the questionnaire into three subscales:

- **Stiffness** (two objects): when first walking and later in the day
- **Physical function** (17 objects): rising from sitting, stair use, bending, standing, getting in/out of a car, walking, shopping, sitting, putting on/taking off socks, getting on/off toilet, rising from bed, lying in bed, getting in/out of bath, light household duties and heavy household duties
- **Pain** (five objects): using stairs, during walking, in bed, lying or sitting and standing.

The WOMAC is available in 65 different language forms (*Physiopedia*, 2021a). No permission to use the WOMAC is needed, as the PDF version of the WOMAC is freely available (*Penn Medicine Princeton Health*, 2021).

The questions are scored on a scale of 0-4, which indicates: none (0), mild (1), moderate (2), severe (3), and extreme (4).

The scores for each subscale give a possible score range of 0-20 for Pain, 0-8 for Stiffness, and 0-68 for Physical Function. The total of all three subscales gives a total WOMAC score.

Thus, a higher score on the WOMAC indicates worse pain, stiffness, and functional limitations (*Physiopedia*, 2021).

3.9.2 The Brief Pain Inventory short form

The Brief Pain Inventory short form (BPIsf), a self-administered survey, can be utilised to measure pain (sensory dimension) and the degree to which it restricts the patient's life (reactive dimension) (Thomazeau *et al*.,2015; Kumar, 2011). The BPI is sensitive to changes in pain intensity and a change of two components on the 11-point scale is clinically significant (Lindberg *et al*. 2016).

A study by Jelsness-Jørgensen *et al*., 2016, found the BPI to be a valid and reliable tool for assessment of pain intensity. Kumar, (2011) agrees with the latter study demonstrating that the BPI has concurrent validity and good construct validity. The BPI is a standardized questionnaire and can be used as both a qualitative and quantitative measure for statistical investigation in research. The BPI has well-established validity and reliability across languages and cultures.

Participants are asked to indicate their highest minimum, average, and current pain intensity, list current management for their pain, their perceived efficiency of pain management and to rate how pain disrupted their overall activity, attitude, ambulatory ability, standard work, and relationships with other people, sleep and pleasure of life on a ten-point scale. The questionnaire consists of nine individual questions, with the last including seven sub-questions. All questions relate to the above-indicated division and a higher score on the scale would indicate higher/increased pain severity.

The BPIsf is a nine-point, self-administered survey that is used to assess the severity of an individual's pain and the effect that the pain has on the individual's everyday functioning. The BPI scale outlines pain as follows: worst pain score: 1 – 4 = mild pain, 5 – 6 = moderate pain, 7 – 10 = severe pain (*London Pain Clinic*, 2021).

The BPIsf is an adaptation of the Brief Pain Inventory – Long Form, which contains additional questions regarding demographics (marital status, date of birth, employment, education), provoking and easing factors, treatment and medication, pain history, pain quality and reaction to treatment. The form falls within the bio-psychosocial model of pain, as it informs aspects including emotional, sensory and function of the pain experience. The BPIsf is also freely available online (*National Palliative Care Research Center*, 2013a).

3.9.3 Short form 36-item Health Survey

The Medical Outcomes Study 36-item Short Form Health Survey (SF-36) is a patient-reported general survey on health status and Health-Related Quality of life (HRQoL), assessing eight dimensions of health (Desmeules *et al.*, 2012). The eight dimensions are: bodily pain, physical functioning, role limitations due to physical health problems, emotional well-being, role limitations

due to personal or emotional problems, energy/fatigue, social functioning and general health perceptions (*National Palliative Care Research Center*, 2013b).

The scoring is a two-step procedure. All the items are scored, but a higher score does not define a more positive health state. Each item is scored on a 0 to 100 range, so that the lowermost and uppermost possible scores are 0 and 100, separately. Scores characterise the percentage of total score accomplished. Items in the same scale are averaged in step two, to produce the 8 scale scores (*RAND Health Care* 2021). The SF-36 documents the calculation of a particular scale for each of the eight dimensions. The total varies from 0 to 100, where 100 shows optimal HRQoL. The validity and reliability of this form is well recognized (Desmeules *et al*., 2012).

The SF-36 is a well-validated questionnaire for HRQoL (Ware and Sherbourne, 1992; Loge and Kaasa, 1998; Jelsness-Jørgensen *et al*., 2016) and was standardized in 1990 as a self-reported measure of well-being and functional health (Heyde *et al*., 2014).

The SF-36 is a measure of health status and a summarised version and is frequently used in health economics as a variable in the quality-adjusted life year calculation to determine the cost-effectiveness of a health treatment. The researcher utilised only a section of the SF-36, as many of the questions included in the SF-36 were included in the other questionnaires included in the study. The researcher was mindful of respondent fatigue in this regard. The SF-36 is also freely available online (*National Palliative Care Research Center*, 2013c).

3.9.4 Hospital anxiety and Depression Scale (HADS)

Hospital Anxiety and Depression Scale (HADS) was originally developed by Snaith and Zigmond (1983) and is generally utilised by clinicians to define the level of self-reported depression and anxiety that an individual is experiencing (Bjelland *et al*., 2002). The HADS is fully standardised; perceives and measures mild grades of mood disorders, depression and anxiety in adults (*gl-assessment*, 2021). The HADS includes fourteen elements that produce ordinal data. Seven of the elements relate to depression and seven relate to anxiety. A study by Pinto *et al*. (2013) disclosed that greater scores indicated higher levels of perceived depression and anxiety and that the core consistency and reliability were acceptable for both depression and anxiety.

The HADS has a total of 14 elements scored on a scale of 0 - 3 (3 indicates higher symptom frequencies). Scores for every subscale (anxiety and depression) range from 0 to 21 with scores characterised as follows: normal 0 – 7, mild 8 – 10, moderate 11 – 14 and severe 15 – 21. Scores for complete scales (emotional distress) range from 0 to 42, with higher scores representing more distress (Bjelland *et al.*, 2002). The questionnaire is also available in other dialects. The standard scoring algorithm was used: anxiety score = sum of items 1*, 3*, 5*, 7, 9, 11*, 13*; and depression = sum of items 2, 4, 6*, 8*, 10*, 12, 14 where starred items are reverse scored. Both subscales have a possible range of 0–21, with higher scores indicating higher anxiety and/or depression. The HADS is also freely available online (*Sexual Violence Research Initiative*, 2021).

3.9.5 EvaSys System

The EvaSys System is a computerized, web-based survey program appropriate for online and paper-based surveys. This special software generates, supports and distributes surveys. EvaSys automatically captures data and results that can then be exported in PDF, Excel, and SPSS and used for data analysis. The four questionnaires, demographic questionnaire, and evaluation forms (pre- and post- operative) were loaded on the system by the researcher and were completed by the participants on a laptop.

3.9.6 Self-developed Demographic Questionnaire

A self-developed demographic information questionnaire was developed by the researcher to gather relevant information regarding age, gender, socio-economic status, co-morbidities etc. (Refer to Appendix VIII) to describe the characteristics of the participants of the study.

3.9.7 Self-developed pre-operative and post-operative evaluation forms

Relevant objective information was obtained during a physical, physiotherapy evaluation pre-operatively and post-operatively and documented on the self-developed pre-operative and post-operative evaluation forms (Appendix IV, V). The impairments measured during the study included body weight measured in kilogram (kg); height in centimetres; knee flexion and knee extension in grades; and Body Mass Index (BMI). The researcher performed all the clinical evaluations of the participants included in the study.

3.9.7.1 Body weight (kg)

Body weight was measured utilising a calibrated SECA scale to the nearest 0.5 kg according to the World Health Organisation guidelines (*World Health organization*, 2017). Individuals had to wear as little as possible clothing as deemed appropriate, without shoes. The scale had to be set to zero before each measurement. The measurement had to be taken three times and the average was taken as the body weight of the individual.

3.9.7.2 Height (cm)

The height of the participants was measured by a portable stadiometer, the Seca Leceister 214, which is manufactured by Seca, Hamburg, Germany. Measurements were taken accurately to the nearest 0.5 cm. The measurements had to be taken three times and the average was taken as the height of the individual.

3.9.7.3 Knee flexion in sitting (degrees)

To measure active-assisted knee flexion, a goniometer was used, and the participant was in a sitting position on a chair. Three sets of flexion measurements were taken and the largest range of flexion in degrees was recorded. The centre point for the measurement was palpated at the articular cavity between the femur and the tibia (joint line). One arm was parallel with the femur and the other arm parallel to the lower leg. Normal range of knee flexion is indicated as 0˚ - 134˚.

Although there are several types of goniometers on the market, the most used instrument to measure knee joint angles in physiotherapy is still a full-circle manual goniometer, labelled as the universal goniometer (UG) (Russel *et al*., 2003). Measurements with the UG have shown good intra- and interrater reliability respectively (ICC 0.98–0.99; ICC 0.86–0.90) (Watkins *et al*., 1991). The majority of these studies have shown higher reliability for knee flexion than knee extension (Brosseau *et al*., 2001, 1997; Watkins *et al*., 1991; Rothstein *et al*., 1983), which also was confirmed by a smartphone-based application (Mehta *et al*., 2017). Knee ROM measurements with the UG are validated compared to X-ray measurements (r = 0.97–0.98), which is considered the gold standard (Gogia *et al*., 1987). However, UG measurements of the lower extremity have shown a measurement error of five degrees (Boone *et al*., 1978), which may be explained by the slight rotation of the tibia in extension (Harrison, 1978; Lehmkuhl & Smith, 1983). This has been confirmed by measuring knee flexion in patients with osteoarthritis (Edwards *et al*., 2004). There

is even a lack of agreement with small knee extension angles, from approximately 15° of extension toward hyperextension (Enwemeka, 1986). The advantages of UG are the low costs and the easy storage for clinical use. However, both hands are needed, making it difficult to stabilise body segments during measurements (Watkins *et al*., 1991). A correct measurement requires a clear visual estimation for alignment and measurement reading (Gajdosik & Bohannon, 1987). The challenge handling the UG may lead to the use of visual estimation of joint ROM, leading to inconsistent results. In keeping with this, most studies confirm that visual estimation is less valid and reliable than the UG (Piriyaprasarth & Morris, 2007; Watkins *et al*., 1991). However, in a small study comparing five goniometers, the UG was almost as inaccurate as visual estimation (Hancock *et al*., 2018).

3.9.7.4 Knee extension in sitting (degrees)

Active-assisted extension range of motion was also determined by the researcher with a goniometer while the participant was sitting in a chair as a starting position. The measurement was taken three times, up to where the participant indicated it was comfortable and the largest range of motion in degrees was recorded as the measurement for the knee extension range of motion. The goniometer was positioned with one arm parallel to the femur and the other parallel to the tibia. A cylinder roll was placed underneath the heel of the foot to allow the knee to extend as much as possible (Jakobsen et al., 2010).

3.9.7.5 Body mass index (BMI)

The body max index was calculated by the researcher using the following equation:

BMI = $\frac{weight\ (kg)}{Height\ (m)^2}$

The calculation for BMI is the same for both genders.

3.9.7.6 Oedema of the knee

Oedema of the knee was measured by the researcher utilising a tape measure. The oedema was measured at the level of the joint line in centimetres and compared. The measurement was taken three times and the average was calculated and recorded as the final measurement.

The measurement and reproducibility of knee circumference in patients with knee OA were examined and performed by da Silva *et al*., (2014), using a tape measure. The study used the

superior pole of the patella as a reference point, where other studies used the centre of the patella; knee circumference (Matthews et al., 2019), 10 cm above the superior pole of the patella (Loyd *et al*., 2021) or 10 cm below the patella (Tornatore *et al*., 2020). The study performed by da *Silva et al*., (2014), according to the intraclass correlation coefficient (ICC), observed a strong correlation (ICC = 0.98) between the two raters and concluded that the use of a measuring tape, as a resource to measure knee circumference in individuals with osteoarthritis is a reliable and reproducible method.

The purpose of the Loyd *et al*. 2021 study was to provide reliable and precise parameters for single frequency bioelectrical impedance assessment (SF-BIA), and for measuring post-TKA lower extremity swelling. In addition, a comparison was made with circumferential measures (CM). Reliability of the measures were calculated using Intraclass Correlation Coefficients (ICC). SF-BIA was found to have a better reliability following surgery compared to CM (ICC = 0.99 vs 0.68). These results indicated that SF-BIA improved the precision and reliability of swelling measurement compared to CM.

Other possible oedema measurements indicated could be girth measurement: a figure eight (preferred in ankle and hand swelling) or circumferential method (*Physiopedia*, 2022). The researcher however decided to use the joint line as centre point for the measurement as this would be more consistent and accurate using the same centre point for pre-operative and post-operative measurements. Not all the participants were content that a marking pen could be used to mark the centre point, one centimetre below the patella as utilised in the Jakobsen *et al*. (2010) study.

3.9.7.7 Alignment of the knee

The alignment of the knee was classified as a normal alignment, Genu Valgum or Genu Valgus pre-operatively and post-operatively. Genu varum is sometimes referred to as bowlegs and genu valgum as knock-knees. Observation on the side of the experienced researcher was used to classify the alignment of the participant's knee.

3.10 Pilot study

After ethical clearance was obtained from the Health Sciences Research Ethics Committee of the University of the Free State a pilot study was conducted utilising the first three participants who met the inclusion criteria (p50), from 1 March 2019, from the orthopaedic surgeons referring patients to the researcher for the purpose of the study. The pilot study was performed to identify shortcomings and possible limitations to the study and to determine if any improvements could be made to the questionnaires and the objective physical evaluation to ensure better outcomes of the study. The results of the pilot study would be included in the final study results if no major changes were made to the measurement instruments. No changes were made after the pilot study and therefore the results of the pilot study were included in the main study.

3.11 Method

Ethical clearance was obtained from the Health Sciences Research Ethics Committee of the University of the Free State (UFS-HSD2017/1527/2509), and permission was also obtained from the General Manager of the private hospital and the individual surgeons from the private hospital where the research study took place before the pilot study and commencement of the main study. The researcher made individual appointments with the hospital manager as well as with each of the orthopaedic surgeons, and during these meetings the researcher provided the doctor / manager with a consent form (Appendix II) in English and a copy of the study information. English is the official communication language of the private hospital group (Appendix I and II). During these meetings, the doctor or hospital manager provided written informed consent for patients (Appendix III) to be recruited for the purpose of the study.

The researcher visited potential participants in hospital pre-operatively and explained the aim and the procedure of the study in person to the possible participant. Any questions the possible participant had were answered by the researcher, after which informed consent was obtained. The researcher took the participant to a private room in the ward where the body weight of the participant was determined. A calibrated SECA scale available in the ward was used to determine the participant's body weight to the nearest 0.5 kg. The participants wore pyjamas and were without shoes/slippers. The scale was set on zero before the participant was instructed to step on the scale. The time of the day and whether the participant had a meal was noted on the data form. As most of the measurements were taken in the evenings, all the participants had supper. The participant was instructed to stand still and look straight ahead while the researcher noted

the weight indicated on the scale. In each instance, the weight was taken three times (the participant had to step off the scale in each instance and step on it again) and the average was calculated and noted on the evaluation form. The body weight was not determined post-operatively due to logistical challenges and is noted as a limitation of the study in the discussion.

A SECA stadiometer was utilised by the researcher to determine the height of the participant. Measurements were determined to the nearest 0.5 cm. Participants were asked to stand barefoot with their heels and back against the wall for the measurement. The measurement was taken without shoes/slippers. In each instance, the height was taken three times and the average was calculated and noted on the evaluation form. All three measurements were taken in a separate room, to protect the privacy of the participant. The height of participants was not determined post-operatively due to logistical challenges and is noted as a limitation of the study in the discussion.

The participant was taken back to his/her bed and was instructed to sit in a chair. Privacy was ensured by closing the hospital curtains. While sitting in the chair, the participant's articular cavity between the femur and the tibia was palpated by the researcher. The researcher placed one arm of the goniometer parallel with the femur and the other arm parallel to the lower leg of the participant. The participant was asked to slide their heel with assistance of the researcher towards the back, while the researcher measured knee flexion with a goniometer. Three sets of flexion measurements were taken and the largest range of flexion in degrees was recorded by the researcher on the evaluation form.

Active-assisted knee extension range of motion was also measured with the participant in a seated position in a chair with the instruction to the participant to straighten their leg in front of them with assistance from the researcher. Three sets of extension range of motion measurements were taken, and the largest range of motion in degrees was recorded on the evaluation form. The researcher placed the one arm of the goniometer parallel to the femur and the other arm parallel to the tibia to ensure accuracy of the measurement.

The participant was then instructed to get into bed to enable the researcher to measure the circumference of the knee bilaterally. A measuring tape was utilised for this purpose. The oedema was measured at the level of the joint line in centimetres and compared with the other knee. The measurement was taken three times and the average was recorded on the evaluation form by the researcher.

After the clinical examination was completed, a thorough explanation of how the questionnaires should be completed on the laptop was done by the researcher. The researcher assisted the participant in completing the questionnaires in instances where assistance was needed. Care was taken to ensure that the data was saved during completion of the questionnaires and that all questions were answered by the participants. The objective evaluation as well as completion of the questionnaires on the laptop took approximately 45 minutes. This data was viewed as baseline data by the researcher.

The researcher requested the participants to send a text message to the researcher to confirm their appointment for their six-week follow-up with the orthopaedic surgeon, which then allowed the researcher to diarise the appointments. The researcher confirmed the appointment with the participant for the six-weeks data collection a week before the appointment and again a day before their scheduled appointment to ensure compliance. The researcher met with the participant on the day of the appointment in the doctor's practice, where the same procedure was followed as with the baseline data. The only exception was the measurement of body weight and height as indicated earlier as the doctor's practice did not have a standardised SECA stadiometer or scale available.

The body mass index of each participant was determined, pre-operatively, by the researcher using the following equation to calculate the BMI.

BMI = $\frac{weight\ (kg)}{Height\ (m)^2}$

The BMI was noted on the evaluation form by the researcher and each participant was then classified by the researcher as either being underweight, normal weight, overweight or obese according to the World Health Organisation's classification of BMI. Underweight: BMI < 18.5; Normal weight: BMI 18.5-24.9; Overweight: BMI 25-30; Obese: BMI ≥ 30 (obese class I 30.0 – 34.9 and obese class II 35.0 – 39.9 (*World Health Organization Europe*, 2021).

3.12 Data analysis

Descriptive statistics namely, percentages and frequencies for categorical data and medians and percentiles for numerical data, were calculated per collection time point. The change between time points were calculated and described by means of Signed Rank test for numerical data and McNemar's test for categorical data. Associations between levels of pain,

functional ability, functionality, HRQoL and BMI were calculated and described by means of Kruskal-Wallis test for numerical data and Chi-square or Fisher's exact test for categorical data. The statistical analysis was done by the Department of Biostatistics, Faculty of Health Science at the University of the Free State.

3.13 Ethical considerations

Ethical clearance was obtained from the Health Sciences Research Ethics Committee of the University of the Free State (UFS-HSD2017/1527/2509), and permission was obtained from the General Manager of the private hospital and four individual surgeons from the private hospital where the research study took place before the pilot study and commencement of the main study. The orthopaedic surgeons asked the participants if they would consider participating in the research study and then only provided the necessary information and referral to the researcher.

Participants received and information letter explaining the aim and objectives of the study and the procedure to be followed during the study. Participants were afforded the opportunity to ask questions to the researcher before the objective evaluation and completion of the questionnaires took place. It was made clear to participants that partaking in the study was voluntary and that if participants wished to withdraw his/her participation, they could do it at any time without any penalty or disadvantage. The researcher's information (email address) was available to the patient and doctor, if any uncertainties or questions were raised.

Participants were also informed that the results of the study and their personal information would be handled with strict confidentiality and that results will only be reported as a group and that no individual data will be provided that would make a participant identifiable. Participants were informed that the results would be made available to the orthopaedic surgeons and the private hospital under the conditions as stipulated above. If necessary, the participants were informed that they could receive the results of the study upon request. Complete confidentiality could, however, not be ensured as data may be provided in the case of a legal inquiry or ethics committee audit. Each participant received a unique number on the main list, which only the researcher had access to. The researcher guaranteed that all material on the laptop was password protected.

The participants were informed that they would not receive any remuneration for partaking in the study and that they would not incur any additional costs to take part in the study. The

physiotherapy evaluation is viewed as standard procedure before an arthroplasty and forms part of the preparation of the procedure. Privacy of the patient was ensured by the researcher by taking the participant to a private room for the measurement of body weight and height and closing the hospital curtains during completion of the questionnaires and the measurements of knee flexion, knee extension and oedema.

No harm was done to participants during the research study, but participants benefitted from a free assessment and free advice by an experienced clinician (researcher). If the researcher identified any complications or concerns, the researcher made use of the necessary referral systems to refer the participant to the appropriate health care professional (using the specialist's choice of health practice) for further management (physiotherapy, psychiatry etc.). Any additional consultations or medical interventions (normal post-operative regime) needed were for the account of the participant.

The official language of the private hospitals is English and therefore all information provided to the orthopaedic surgeons as well as the patients were provided in English. For the same reason, the questionnaires were provided in English as the standardised questionnaires were freely available online in English. All the questionnaires utilised in the study were standardised, which increased the validity and reliability of the study.

According to good clinical practice, the population was not seen as a vulnerable population, due to the relevant procedure being elective as well as choosing the specific orthopaedic surgeon to perform the surgery.

The data will be stored and kept for a minimum of 10 years for clinical trials according to Good Clinical Practice Guidelines (*South African Health Products Regulatory Authority*, 2021). Thereafter, all data will be deleted by the researcher.

The methodology was clearly stipulated in this chapter. The next chapter provides the results obtained pre- and post-operatively.

4. Results

In this chapter, the results of both the physical evaluations and questionnaires will be presented. Measurements were obtained on two occasions, pre- and post-operatively. Convenience sampling was utilised and the investigative period was six weeks. All the participants completed the questionnaires as far as possible and no participant withdrew voluntary. The results of the study are illustrated with the use of tables and diagrams. Data were not normally distributed; therefore, data analyses were conducted using non-parametric statistical methods and are reported as medians and quartile ranges. Statistical significance was set as $p > 0.05$ at a 95% level of confidence for this study.

In Table 1, please find the results of the self-administered demographic data that was completed pre-operatively.

Table 1 - Demographic information of participants pre-operatively (n=41)

Variable	**Category**	**Number of participants (n=41)**
Age		65 years (median)
Gender	Male	13 (31.7%)
	Female	28 (68.3%)
Home language	Afrikaans	29 (70.7%)
	English	6 (14.6%)
	Sesotho	4 (9.8%)
	Other	1 (4.9%)
Marital status	Married	31 (75.6%)
	Single	3 (7.3%)
	Divorced	1 (2.4%)
	Living together	0 (0%)
	Widow/widower	6 (14.6%)
Household living status	Alone	4 (9.8%)
	Family	33 (80.5%)
	Other	1 (2.4%)
	Old age home	3 (7.3%)
Initial diagnoses	Rheumatoid arthritis	1 (2.4%)
	Osteo-arthritis	40 (97.6%)
	Other	0 (0%)
Employment status/type	Hard labour	8 (19.5%)

	Office work	14 (34.2%)
	Other	18 (43.9%)
	Retired/ pension	1 (2.4%)
Duration of symptoms	2.5 years (median)	40 (97.6%)
Use of walking aid	Yes	13 (33.3%)
	No	26 (66.7%)
Chronic illness	*Diabetes	6 (14.6%)
	Hypertension	29 (70.7%)
	Cancer	1 (2.4%)
	Asthma	3 (7.3%)
	Other	2 (4.9%)
Highest educational level	High school	21 (51.2%)
	Primary school	17 (41.5%)
	College/university	3 (7.3%)
Knee Replacement side	Left	19 (46.3%)
	Right	22 (53.7%)
Number of knee replacements	First	32 (78.1%)
	Second (Contralateral leg)	9 (22.0%)
Any other joint Osteoarthritis	No	23 (56.1%)
	Yes	18 (43.9%)
Smoking	No	1 (2.4%)
	Yes	39 (95.1%)
	Sometimes	1 (2.4%)

* Participants were not required to indicate diabetes mellitus type I or II

The majority of the participants, 28 (68.29%) were females and 13 (31.71%) were males. Thirty-one of the participants (75.61%) were married and 29 (70.73%) spoke Afrikaans as a home language. Most of the participants, 33 (80.49%) indicated that they lived with their family. Forty participants (97.56%) indicated that they were initially diagnosed with osteoarthritis and the median duration for knee symptoms was 2.5 years. Thirteen participants (33.33%) indicated that they used a walking aid before the surgery and hypertension was listed as the most common (prevalent) chronic disease participants were living with. In 22 (53.66%) participants, the right side received the knee replacement and 32 (78.05%) participants indicated that this was their first knee replacement. Most of the participants (39 (95.12%)) were smokers.

4.1 Pre-operative and post-operative anthropometric measurements, impairments and or activity limitations

The following information was obtained before the participants completed the pre-operative questionnaire and six weeks later, the post-operative questionnaire during the follow-up visit.

Impairments are problems in body function or structure such as a significant deviation or loss, while activity limitations are difficulties an individual may have in executing activities (*World Health Organization*, 2021). In Table 2 below, information regarding body weight, height, BMI, knee flexion and -extension are provided as obtained during the pre- and post-operative evaluation.

Table 2 – Measurements of participants during the pre-operative evaluation (n=41) and post-operative evaluation (n=30)

Variable	Pre-operative (n=41)	Median Pre-	Interquartile range	Post-operative (n=30)	Median Post-	Interquartile range
Body weight	41	88 kg	75 -102 kg	* Not determined		
Height	39	1.69 cm	1.59 -1.77cm			
BMI	41	31	28 -36			
Knee flexion	39	113.33°	90°-122.33°	30	98.33°	91.66°-112.33°
Knee extension	39	1.66°	0°- 5.0°	29	0°	0°- 2.33°

*The body weight, height and BMI were not measured post-operatively due to logistical reasons.

4.1.1. Difficulty in climbing stairs

Participants were asked to indicate if they had difficulty in climbing stairs. They had to indicate whether ascending, descending or if both were difficult to perform

Represented in Figure 1 below, the number of participants having difficulty navigating stairs are depicted.

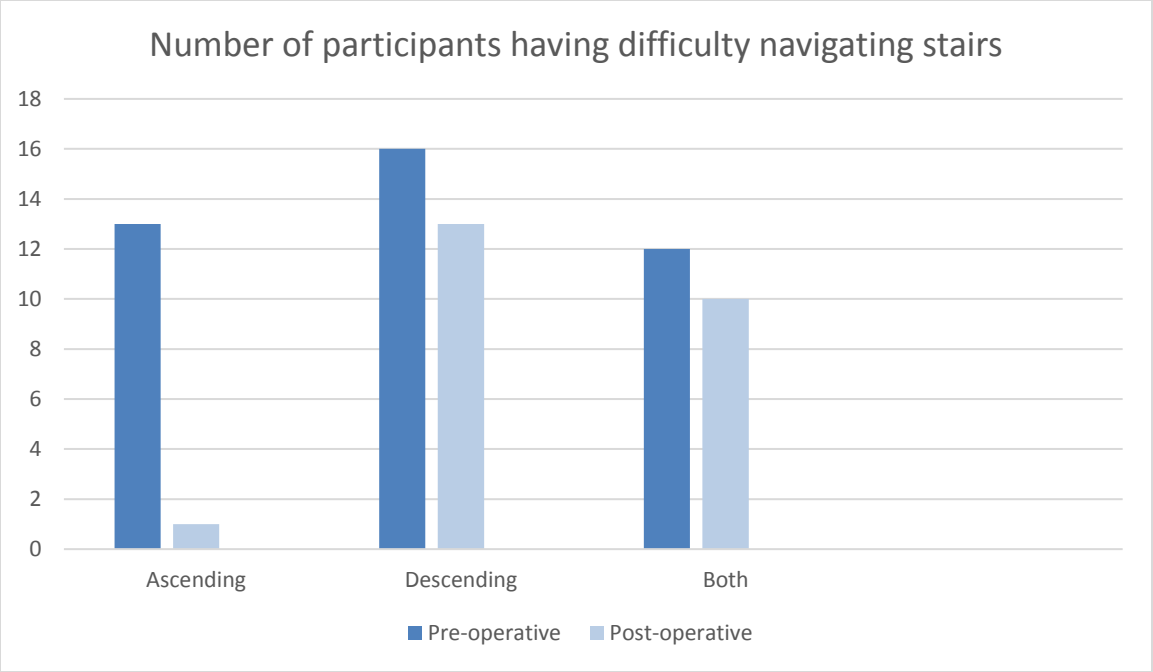

Figure 1: Number of participants having difficulty navigating stairs pre-operatively (n=41) and post-operatively (n=31)

Descending stairs were more problematic for 16 of participants pre- and for 13 participants post-operatively. The McNemar test was used to determine the statistically significant difference between descending stairs, pre- and post-operatively. A *p*-value of 0.023 ($p < 0.05$) was found at a 95% level of confidence. The change from pre-operatively to post-operatively was thus statistically significant, which indicates that patients found it easier to climb stairs post-operatively as compared to pre-operatively.

4.1.2 Oedema of the knee

Whether participants experienced challenges with oedema of the knee was explored in the pre- and post-operative questionnaires. The question posed to participants was if they experienced any swelling of the knee.

Table 3 below represents the median measurement pre- and post-operatively for oedema of the affected knee. The left knee measurements were taken pre- and post-operatively and compared with the left knee group, while the same was done for the right knee group. Additionally, the inter-quartile range is included, which indicates the measurements at 25% (lower quartile) of measurements as well as the measurement at 75% (upper quartile) of all measurements. This range between 25% and 75% of measurements is known as the inter-quartile range (IQR) and

shows the variation of the measurements taken within the sample. A bigger IQR would indicate more variation within measurements, while a smaller IQR would indicate a smaller variance in measurements. Since this data was analysed with non-parametric statistics, IQR is used, instead of the norm for parametric statistical methods that would include standard deviation.

Below in Table 3, the number of participants having difficulty with oedema of the knee are represented.

Table 3 – Oedema measurements of participants during the pre-operative evaluation (n=38) and post-operative evaluation (n=31)

Variable	Median (cm) Pre-operatively	Number of participants Pre-operatively (n=38)	Median (cm) Post-operatively	Number of participants post-operatively (n=31)	IQR of mean difference	Median (difference pre- and post-operative)	Signed rank test
Oedema of the knee		37					*p*=1.000
Left knee	43 cm		45 cm		[1; 4]	2 cm (n=22)	***p*=0.004***
Right knee	42 cm		43 cm		[0; 3]	2 cm (n=19)	*p*=0.280

*Statistically significant

Of the 38 participants, 37 (97.37%) participants indicated that they experienced oedema of the knee. The median measurement of the left knee was 43 cm and 42 cm for the right knee. Post-operatively, the median measurement of the left knee was 45 cm (n=22) and of the right knee 43 cm (n=19). The change between pre-and post-operative oedema was calculated for both knees for statistical significance by using the McNemar test. The *p* - value with this test showed that *p* = 1.000. The change in oedema of the knees is thus not statistically significant pre-operatively as compared to post-operatively (six weeks).

For the right knee (n=19), a median of 2 cm with an IQR (inter quartile range) of [0; 3] and *p* = 0.280 was found. For the left knee (n=22), a median of 2 cm and an IQR of [1; 4] and *p* = 0.004 was found. To test for statistical significance of change found pre-operatively to post-operatively, the *p* – values were calculated using the Signed Rank test.

From the results in Table 3, it is clear that the *p*-values found for the oedema on the left knees (pre-operatively and post-operatively) was found to be $p = 0.004$ and statistical significance is indicated. For the right knees, on the other hand, a *p*-value of $p = 0.280$ was found. From the results, it can be concluded that only the left knees showed a statistically significant change in oedema from pre-operatively to post-operatively, with statistically significant more oedema post-operatively as compared to pre-operatively.

4.1.3 Alignment of the knee

The alignment of the knee was evaluated as normal alignment, Genu Valgum or Genu Valgus pre-operatively.

Table 4 – Alignment of participants' knees during the pre-operative evaluation (n=38)

Variable	Pre-operatively (n=38)
Normal alignment	22 (57.9%)
Genu Valgum	14 (36.8%)
Genu Varus	2 (5.3%)

It was noted that 22 patients presented with a normal knee alignment; 14 with Genu Valgum; and two with Genu Varus. Post-operatively, 22 (96.77%) participants presented with normal alignment.

4.1.4 Onset of knee pain

The longest onset of knee pain was 42 years, while the shortest onset was three months.

4.1.5 Comparable sign

The participants had to indicate which movement was the most painful: knee flexion, knee extension or weight-bearing. This is reflected in Table 5. Knee flexion was indicated by 18 (n=40) participants as a painful movement.

Table 5 – Most painful movement/comparable sign indicated by participants

Variable	Pre-operative n=40	Number of participants Pre-operatively (n=40)	Post-operative n=31	Number of participants post-operatively (n=31)	Signed rank test
Knee flexion	40	18 (45%)	30	11 (37.7%)	*p*=0.227
Knee extension	40	6 (15.0%)	31	7 (22.6%)	***p*=0.048***
Weight-bearing	40	23 (57.5%)	30	5 (17.7%)	
Other	40	12 (Sitting) (30%)	31	5 (Sitting) (16.1%)	

* Statistically significant

The *p*-value as calculated by the Signed Rank test for knee extension is *p*=0.048. Thus, the change in extension of the knee is statistically significant from pre-operative to post-operative, with extension being more difficult for the patient to achieve after the surgery.

The most painful movement indicated by participants, pre- and post-operatively, was sitting. The painful movement is also known as the comparable sign in physiotherapy terminology. Geoffrey Maitland developed the concept "**comparable sign**(s) (CS), which are physical examination findings related to the main complaint(s) of the patient that are reproduced during an examination/treatment (Cook *et al.*, 2015). These may include observed abnormalities of movement, posture or motor control, static deformities, abnormal responses to movement, range of motion and abnormal joint assessment findings (Cook *et al.*, 2015). Other painful movements that were also mentioned by participants included sitting to standing (n=2), standing for a long time (n=2) and walking (n=1). Knee flexion, however, produced the most familiar pain that participants complained of pre-operatively.

4.1.6 Physiotherapy treatment received before, during and after surgery

The participants had to indicate if they received physiotherapy treatment before their surgery.

Post-operatively, participants had to indicate whether they received physiotherapy rehabilitation/management in hospital and during discharge and the six-week follow-up. Table 6 below provides the answer to the questions posed above.

Table 6 – Physiotherapy treatment patients received before, during and after surgery

Physiotherapy treatment	n =40	Frequency
Before surgery	1 participant	Once a week for less than four weeks
During stay in hospital	18 participants	1-3 days in hospital
Between discharge and six-week follow-up	29 participants	
Biokinetics before surgery	1 participant	

4.1.7 Other medical treatment received by participants

The participants were asked if they received any other medical treatment before or after surgery. There was no indication of a medical intervention pre-operatively.

Post-operatively, 29 (96.7%) participants indicated that they did not need any other medical treatment (for example, general practitioner) after their surgery, except that one participant indicated that he/she received anti-coagulants after a thrombosis.

4.1.8 Booklet information received by participants

Ninety-three and a half per cent of participants (29) received an information booklet from their surgeon before their surgery.

4.2 Brief pain Inventory (BPI)

The pain severity of patients pre- and post-operatively was determined using a standardised questionnaire, the Brief Pain Inventory short form (BPIsf), utilised to measure the severity of pain and the degree to which it restricts the patient's life or ADL.

The participants were asked to indicate their highest minimum, average and current pain intensity; list current management for their pain; their perceived efficiency of pain management; and rate how pain disrupted their overall activity, attitude, ambulatory ability, standard work and relationships with other people, sleep and pleasure of life on a ten-point scale. The questionnaire consists of nine individual questions, with the last including seven sub-questions. All questions

relate to the above-indicated division and a higher score on the scale would indicate more severe pain.

The standardised questionnaire can be found in Appendix VI (p167). All participants that attended both pre- and post-operative visits completed the questionnaire in a self-administered fashion. Please refer to individual tables below reflecting the responses to the questions posed in the questionnaire.

4.2.1 Participants experiencing everyday kinds of pain

Participants were asked if they experienced pain other than everyday kinds of pain, including minor headaches, sprains and toothache. The responses provided are indicated in Table 7 below.

Table 7 – Participants experiencing pain

	Pre-operative pain **n = 41**	**Post-operative pain** **n = 31**
Experiencing pain	40 (97.6%)	31 (100%)

Pre-operatively, 40 (97.6%) participants indicated that they experienced pain that differed from everyday kinds of pain and one participant indicated that they did not experience any pain. Post-operatively, 30 (100%) participants indicated that they experienced pain that differed from everyday kinds of pain.

4.2.2 Sites of pain indicated by participants

Most of the participants reported pain at more than one site. Pre-operatively, the most common site of pain was on the medial side of the knee joint, with eight participants complaining; while post-operatively, 14 participants indicated that they experienced pain on the medial side of the knee joint.

In Table 8 below, the indication by participants of their sites of pain:

Table 8 – Sites of pain

Pre-operatively (n=40)	Count (n)	Post-operatively (n=31)	Count (n)
Anterior knee	5 (12.5%)	Anterior knee	5 (16.1%)
Medial knee	8 (20.0%)	Medial knee	14 (45.2%)
Posterior knee	3 (7.5%)	Posterior knee	3 (9.7%)
Medial/Anterior knee	3 (7.5%)	Medial/Anterior knee	1 (3.2%)
Lateral knee	0 (0%)	Lateral knee	4 (12.9%)
Anterior and posterior	6 (15.0%)	Anterior and posterior	0 (0%)

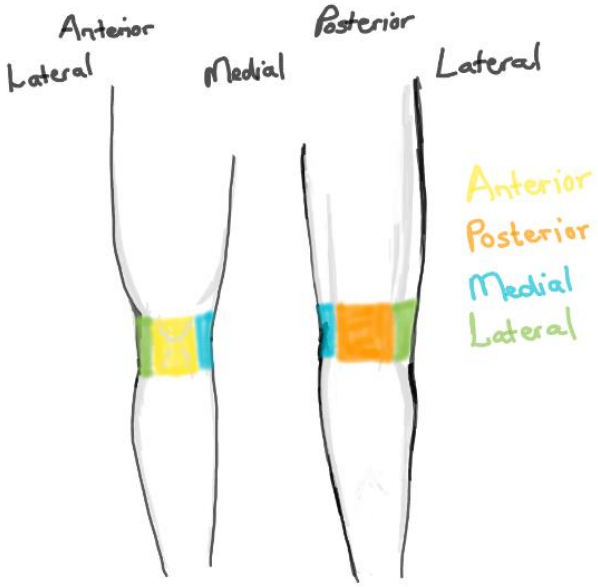

Figure 2 - Sites of pain – indicated pre- and post-operatively on body charts

The medial aspect of the knee was the area that was indicated by the largest number of participants (n=8, 20.0%), followed by both anterior/posterior knee pain - which was indicated by six (15.0%) participants, followed by anterior knee pain as indicated by five (12.5%) participants.

4.2.3 Pain descriptors of the Brief Pain Inventory

The pain severity scale was determined by using the BPI questionnaire.

The following four items where measured:

1. pain at its worst in the last 24 hours
2. pain at its least in the last 24 hours
3. pain on average
4. pain participants experience while completing the questionnaire.

An average, pain severity was calculated by dividing the four item scores by four.

Worse or more severe pain was indicated by a higher score on the Pain Severity scale.

The pain is measured on a 1-10 Likert scale by participants. For the purpose of presenting the data for this study, a score of 0-3 indicates mild pain, 4-6 moderate pain and 7-10 severe pain. The overall results can be seen in Table 9.

Table 9 – Pain descriptors in last 24 hours

Brief pain inventory		**Pre-operatively (n=40)**	**Post-operatively (n=30)**	**Change (pre- post-operatively)**		
				Median Difference	IQR of median difference	*Signed Rank test*
Worst pain				-1	-2;1	p=0.09
	Mild	2 (5.0%)	2 (6.67%)			
	Moderate	3 (7.5%)	2 (6.67%)			
	Severe	35 (87.5%)	26 (86.7%)			
Least pain				0	-1; 1	p=0.99
	Mild	31 (77.5%)	22 (73.3%)			
	Moderate	9 (22.0%)	7 (23.3%)			
	Severe	0 (0%)	0 (0%)			
Average pain				-1	-2; 0	**p=0.01***
	Mild	4 (10.0%)	0 (0%)			
	Moderate	31 (77.5%)	9 (30.0%)			
	Severe	5 (12.5%)	21 (70.0%)			
Pain while completing questionnaire				1	-1; 1	p=0.90
	Mild	29 (72.5%)	22 (73.3%)			
	Moderate	7 (17.5%)	7 (23.3%)			
	Severe	3 (7.5%)	0 (0%)			

*Statistically significant

From Table 9, it can be seen that fewer participants had severe pain post-operatively. Also noted is that the **least** pain experienced by the participants was mild pain.

The change in pain recorded in the past 24 hours at the time of **average** pain experienced, shows to be statistically significant between pre- and post-operatively, with the pain being reported by participants as being more average after surgery.

The question investigating what treatments or medication were received for treating their pain, participants indicated that they used a variety of Paracetamol and Non-steroidal ant-inflammatory drug (NSAIDS) for pain control pre- and post-operatively.

Participants also had to indicate how much pain relief they experienced by taking medication or pain treatment. Fifteen participants (36.6%) indicated that they had 30% pain relief after taking pain medication pre-operatively. Post-operatively, 13 (43.3%) participants indicated that they had 90% pain relief after taking their medication and 13 (43.3%) of the participants had an 80% relief after they took their medication.

Table 10 – Percentage pain relief medication provided

		Pre-operatively (n=41)	Post-operatively (n=31)	Signed Rank test
Percentage relief medication provided	10%	2 (4.9%)	0	***p*=0.001***
	20%	3 (7.3%)	0 (0%)	
	30%	15 (36.6%)	1 (3.2%)	
	40%	4 (9.8%)	0 (0%)	
	50%	0 (0%)	0 (0%)	
	60%	3 (7.3%)	2 (6.5%)	
	70%	2 (4.9%)	3 (9.7%)	
	80%	5 (12.2%)	13 (43.3%)	
	90%	5 (12.2%)	13 (43.3%)	
	100%	2 (4.9%)	0 (0%)	

*Statistically significant **Statistically highly significant

The signed rank test was used at a 95% confidence level; the *p*-value was statistically significant, indicating that the pain treatment received post-operatively provided participants with pain relief as opposed to no relief pre-operatively.

Fifteen (37.5%) of the participants rated their pain 9/10 and 11 (27.5%) participants rated their pain 8/10. This is indicative of high pain scores as the highest score that could be awarded was

10/10. Post-operatively, 12 (40.0%) of the participants indicated an 8/10 pain, but it seems that the general intensity of pain was less post-operatively.

The participants also rated their pain at its least in the last 24 hours. Pre-operatively 16 (40.0%) participants rated their pain as 3/10 pain and nine (22.5%) participants 2/10 pain. Post-operatively, 18 (60.0%) participants indicated that they experienced a 3/10 pain.

The participants described their pain pre-operatively as average; 29 (72.5%) participants rated their pain as 6/10. An average pain, post-operatively, of 6/10 was indicated by 16 (53.3%) participants

Pre-operatively, 12 participants rated their pain while completing the questionnaires 2/10 and this was viewed as their current pain. Two (5.0%) of the participants indicated that they experienced 8/10 pain at that moment (current pain). Post-operatively, 16 (53.2%) participants indicated a 3/10 pain at that current moment.

4.2.4 Pain interference

The Pain Interference scale of the Brief Pain inventory consists of seven items: general activity; mood; walking ability; normal work; relations with other people; sleep; and enjoyment of life. For the purpose of presenting the data for this study, a score of 0-5 indicates mild interference, 6-7 moderate interference and 8-10 severe interference.

Table 11 - Pain interference with activities in the last 24 hours pre- and post-operatively

Brief pain inventory	**Pain Interference**	**Pre-operatively (n=41)**	**Post-operatively (n=31)**	**Change (pre- post-operatively)**		
				Median Difference	IQR of median difference	*Signed Rank test*
General activity				-1	-2; 0	*p*=0.16
	Mild	0 (0%)	0 (0%)			
	Moderate	8 (19.5%)	16 (51.2%)			
	Severe	30 (73.2%)	15 (48.4%)			
Mood				-2	-4; -1	***p<0.01****
	Mild	0 (0%)	11 (26.8%)			
	Moderate	7 (17.1%)	17 (54.8%)			
	Severe	31 (75.6%	3 (9.7%)			

Walking ability				-2	-3; -1	***p<.01****
	Mild	0 (0%)	7 (22.6%)			
	Moderate	2 (4.0%)	21 (67.7%)			
	Severe	35 (85.4%)	3 (9.7%)			
Normal work (includes both work outside the home and housework) **				-2	-2; -1	***p<0.01****
	Mild	0 (0%)	6 (19.4%)			
	Moderate	9 (21.9%)	22 (70.9%)			
	Severe	30 (73.2%)	3 (9.7%)			
Relations with other people				-2	-3; -1	***p<0.01****
	Mild	3 (7.3%)	12 (38.7%)			
	Moderate	11 (26.8%)	17 (54).8%			
	Severe	23 (56.1%)	2 (6.5%)			
Sleep				-1	-2; 1	*p*=0.31
	Mild	5 (12.2%)	11 (35.5%)			
	Moderate	9 (21.9%)	19 (61.3%)			
	Severe	13 (31.7%)	1 (3.2%)			
Enjoyment of life				-2	-3; -2	***p<.001***
	Mild	**0 (0%)**	**7 (22.6%)**			
	Moderate	6 (14.6%)	20 (64.5%)			
	Severe	31 (75.6%)	2 (6.5%)			

*Statistically significant **Statistically highly significant

There was a statistically significant change post-operatively as shown in Table 11: mood, working ability, normal work, relations with other people and enjoyment of life.

Twenty-two (53.7%) participants indicated a score of 8/10 interference with their general activity, while post-operatively, they indicated a 7/10 (n=14, 45.2%) and 8/10 (n=14, 45.2%) score, which indicated that, despite surgery, pain still interfered with their general activity.

The indication that pain interfered with the participant's mood was shown when 23 (56.1%) participants indicated an 8/10 score (pre-operatively). According to the scale, this would indicate that pain really interfered with their mood. One participant (4.4%) pre-operatively indicated that pain completely interfered with his/her mood. Post-operatively, there was still a strong indication that pain influenced participants' mood, with 10 (32.3%) participants scoring a 7/10 pain.

Twenty-eight (68.3%) participants indicated an 8/10 pain that interfered with their walking ability. A 9/10 score was also indicated by seven (17.1%) participants. Interestingly enough, post-operatively, participants still indicated that they experienced difficulty with walking (n=12, (38.7%), 6/10).

Many participants (n=27, 65.9%) indicated, pre-operatively, an 8/10 pain rating that showed that pain interfered with their normal work (housework and outside the home). After surgery, 14 (45.2%) participants indicated a 6/10 pain for this item.

Relations with other people were influenced with an 8/10 score by 20 (48.8%) participants. Post-operatively, 13 (41.9%) participants indicated a 6/10 influence on their relations with other people.

Pain also interfered with sleeping habits of participants. Thirteen (31.7%) participants scored 8/10 and nine (21.9%) participants 6/10 for disturbance of sleep. Post-operatively, 14 (45.2%) participants (6/10) indicated disturbance of sleep after surgery due to pain.

Twenty-three participants (56.1%) indicated a score of 8/10 pain that affected their enjoyment of life. This score indicated that the pain interfered significantly with their life. A score of 9/10 was given by eight (19.5%) participants. Post-operatively, most participants scored 6/10 (n=31), which showed an increase in enjoyment of life.

4.3. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) are used to measure stiffness, physical function and pain in individuals with knee and/or hip osteoarthritis (OA). To measure the WOMAC, the questions are scored on a scale of 0-4, which indicates: none (0), mild (1), moderate (2), severe (3), and extreme (4) (*Physiopedia*, 2021c). The sum of the three subscales gives a total WOMAC score out of 96. Higher scores on the WOMAC indicate worse pain, stiffness and functional limitations.

The WOMAC contains 24 activities that separate it into three subscales:

- **Stiffness** (two activities): when first walking and later in the day
- **Physical function** (17 activities): rising from sitting, stair use, bending, standing, getting in/out of a car, walking, shopping, sitting, putting on/taking off socks, getting on/off toilet, rising from bed, lying in bed, getting in/out of bath, light household duties and heavy household duties
- **Pain** (five activities): using stairs, during walking, in bed, lying or sitting and standing

The scores for each subscale:

0-20 for pain (experiencing pain during activity of daily living)

0-8 for stiffness

0-68 for physical function

The following results, in Table 12, were obtained for the WOMAC pre- and post-operatively:

Table 12 - Total scale of Pain, stiffness and physical as measured by the WOMAC

WOMAC	Change (pre (n=41) – post (n=31) -operatively)		
	Median	IQR	*Signed Rank test*
Pain	-3	-5; -2	***p<0.01****
Stiffness	-2	-2; -1	***p<0.01****
Physical	-20	-24; -12	***p<0.01****
WOMAC (total score)	-26	-32; -16	***p<0.01****

*Statistically significant

The change between pre- and post-operative findings as measured by the WOMAC was calculated for statistical significance by using the Signed rank test. The *p*-value equals p<0.01 for each of the functionalities measured, which is < 0.05, and thus shows a statistically significant difference found between pre-operative and post-operative perception of pain, stiffness, and physical subscales of the WOMAC. In addition, the total score for the WOMAC comparing pre-operative and post-operative also showed statistical significance, indicating a better WOMAC score post-operatively.

In Table 13, the results for the pain subscale pre- and post-operatively are indicated:

Table 13 – WOMAC subscale Pain

*0 no pain; 1 slight/mild; 2 moderate; 3 very/severe; 4 extremely

Pain	**Scale of difficulty**	**Number of participants pre-operative (n= 41)**	**Number of participants post-operative (n=31)**
Walking	0	1 (2.4%)	0 (0%)
	1	1 (2.4%)	0 (0%)
	2	10 (24.4%)	30 (96.8%)
	3	27 (65.9%)	0 (0%)
	4	2 (4.9%)	0 (0%)
Stair climbing	0	0 (0%)	0 (0%)

	1	1 (2.4%)	4 (12.9%)
	2	10 (24.4%)	27 (87.1%)
	3	25 (60.9%)	0 (0%)
	4	5 (12.2%)	0 (0%)
Nocturnal	0	3 (7.3%)	0 (0%)
	1	10 (24.4%)	9 (29.0%)
	2	16 (39.0%)	19 (61.3%)
	3	10 (24.4%)	3 (9.7%)
	4	2 (4.9%)	0 (0%)
Rest	0	8 (19.5%)	0 (0%)
	1	26 (63.4%)	31 (100%)
	2	6 (14.6%)	0 (0%)
	3	1 (2.4%)	0 (0%)
	4	0 (0%)	0 (0%)
Weight-bearing	0	0 (0%)	2 (6.5%)
	1	4 (9.8%)	26 (83.9%)
	2	16 (39.0%)	3 (9.7%)
	3	19 (46.3%)	0 (0%)
	4	2 (4.9%)	0 (0%)

The change between pre- and post-operative has been calculated only for the WOMAC's three sub-sections and the questionnaire itself. No specific p-values were calculated for each individual question of the WOMAC and compared.

During the first part of the WOMAC measuring, questions were posed to probe participants regarding pain experienced during activities including walking, stair climbing, rest, nocturnal and weight-bearing. Twenty-seven (65.9%) participants indicated that they experienced much difficulty with walking and 10 (24.4%) participants experienced moderate difficulty with walking. Stair climbing was very difficult for 25 (60.9%) participants and provided moderately difficulty for 10 (24.4%) participants. Sixteen participants (39.0%) experienced moderate nocturnal difficulty (difficulty with pain at night). Slight pain at rest was indicated by 26 (63.4%) participants, while weight bearing was perceived by 19 (46.3%) participants as being very difficult and by 16 (39.0%) participants as moderately difficult. During the post-operative part of the WOMAC, 30 (96.8%) participants experienced moderate pain with walking and 27 (87.1%) moderate pain with stair climbing. The nocturnal pain showed to be more problematic for 19 (61.3%) of the participants. Slight pain was indicated by 26 (83.9%) participants for weight-bearing and slight pain in 31 (100%) participants during rest.

In Table 14, the results for the stiffness subscale pre- and post-operatively are indicated:

Table 14- WOMAC subscale Stiffness

*0 no pain; 1 slight/mild; 2 moderate; 3 very/severe; 4 extremely

Stiffness	Scale of difficulty	Number of participants pre-operative (n=41)	Number of participants post-operative (n=31)
Morning stiffness	0	0 (0%)	0 (0%)
	1	1 (2.4%)	1 (3.2%)
	2	11 (26.9%)	28 (90.3%)
	3	29 (70.7%)	2 (6.5%)
	4	0 (0%)	0 (0%)
Stiffness occurring later in the day	0	0 (0%)	0 (0%)
	1	1 (2.4%)	4 (12.9%)
	2	15 (36.6%)	26 (83.9%)
	3	25 (60.9%)	1 (3.2%)
	4	0 (0%)	0 (0%)

Twenty-nine (70.7%) participants indicated that they experienced much difficulty with morning stiffness and 11 (26.9%) participants indicated that they experienced moderate difficulty. Stiffness occurring later in the day was experienced by 25 (60.9%) participants and moderate difficulty by 15 (36.6%) participants.

With the second part, 28 (90.3%) participants indicated moderate morning stiffness and 26 (83.9%) participants moderate stiffness occurring later in the day.

In Table 15, the results for the physical function subscale pre- and post-operatively are indicated:

Table 15– WOMAC subscale Physical function

*0 no pain; 1 slight/mild; 2 moderate; 3 very/severe; 4 extremely

Physical Function	Scale of difficulty	Number of participants pre-operative (n= 41)	Number of participants post-operative (n=31)
1.Descending stairs	0	1 (2.4%)	0 (0%)

	1	0 (0%)	7 (22.6%)
	2	10 (24.4%)	24 (77.4%)
	3	26 (63.4%)	0 (0%)
	4	4 (9.8%)	0 (0%)
2. Ascending stairs	0	0 (0%)	0 (0%)
	1	3 (7.3%)	18 (58.1%)
	2	14 (34.1%)	13 (41.9%)
	3	21 (51.1%)	0 (0%)
	4	3 (7.3%)	0 (0%)
3. Rising from sitting	0	1 (2.4%)	0 (0%)
	1	3 (7.3%)	8 (25.8%)
	2	4 (9.8%)	23 (74.2%)
	3	30 (73.2%)	0 (0%)
	4	3 (7.3%)	0 (0%)
4. Standing	0	1 (2.4%)	0 (0%)
	1	2 (4.9%)	23 (74.2%)
	2	13 (31.7%)	7 (22.6%)
	3	23 (56.1%)	1 (3.2%)
	4	2 (4.9%)	0 (0%)
5. Bending to the floor	0	1 (2.4%)	0 (0%)
	1	2 (4.9%)	25 (80.6%)
	2	16 (39.0%)	6 (19.4%)
	3	19 (46.3%)	0 (0%)
	4	3 (7.3%)	0 (0%)
6. Walking on flat surface	0	1 (2.4%)	0 (0%)
	1	6 (14.6%)	26 (83.9%)
	2	20 (48.8%)	5 (16.1%)
	3	13 (31.7%)	0 (0%)
	4	1 (2.4%)	0 (0%)
7. Getting in/out car	0	0 (0%)	0 (0%)
	1	1 (2.4%)	18 (58.1%)
	2	8 (19.5%)	12 (38.7%)
	3	32 (78.0%)	1 (3.2%)
	4	0 (0%)	0 (0%)
8. Going shopping	0	1 (2.4%)	0 (0%)
	1	2 (4.9%)	22 (70.9%)
	2	12 (29.3%)	9 (29.0%)
	3	24 (58.5%)	0 (0%)
	4	2 (4.9%)	0 (0%)
9. Putting on socks	0	1 (2.4%)	1 (3.2%)

	1	4 (9.8%)	28 (90.3%)
	2	29 (70.7%)	2 (6.5%)
	3	7 (17.1%)	0 (0%)
	4	0 (0%)	0 (0%)
10. Lying in bed	0	1 (2.4%)	0 (0%)
	1	6 (14.6%)	29 (93.5%)
	2	20 (48.8%)	2 (6.5%)
	3	13 (31.7%)	0 (0%)
	4	1 (2.4%)	0 (0%)
11. Taking off socks	0	1 (2.4%)	1 (3.2%)
	1	4 (9.8%)	27 (87.1%)
	2	30 (73.2%)	2 (6.5%)
	3	6 (14.6%)	0 (0%)
	4	0 (0%)	0 (0%)
12. Rising from bed	0	2 (4.9%)	0 (0%)
	1	1 (2.4%)	21 (67.7%)
	2	12 (29.3%)	10 (32.3%)
	3	25 (60.9%)	0 (0%)
	4	0 (0%)	0 (0%)
13. Getting in /out bath	0	2 (4.9%)	0 (0%)
	1	0 (0%)	22 (70.9%)
	2	9 (21.9%)	8 (25.8%)
	3	27 (65.9%)	1 (3.2%)
	4	3 (7.3%)	0 (0%)
14. Sitting	0	1 (2.4%)	0 (0%)
	1	2 (4.9%)	12 (38.7%)
	2	10 (24.4%)	16 (51.6%)
	3	26 (63.4%)	3 (9.7%)
	4	2 (4.9%)	0 (0%)
15. Getting on/off toilet	0	1 (2.4%)	0 (0%)
	1	1 (2.4%)	17 (54.8%)
	2	11 (26.8%)	14 (45.2%)
	3	27 (65.9%)	0 (0%)
	4	1 (2.4%)	0 (0%)
16. Heavy domestic duties	0	0 (0%)	0 (0%)
	1	1 (2.4%)	1 (3.2%)
	2	9 (21.9%)	8 (25.8%)
	3	25 (60.9%)	12 (38.7%)
	4	6 (14.6%)	2 (6.5%)
17. Light domestic duties	0	0 (0%)	0 (0%)

	1	3 (7.3%)	8 (25.8%)
	2	32 (78.0%)	23 (74.2%)
	3	5 (12.2%)	0 (0%)
	4	1 (2.4%)	0 (0%)

In Table 16, the physical functional activities are summarised, showing the degree to which patients perceived difficulty in doing certain activities, pre- and post-operatively.

Table 16 Summary of activities changing between pre- and post- operative

Activity	**Pre- /post-operatively**	**1 Slight /mild**	**2 Moderate**	**3 Very/severe**	**4 Extremely**
Descending stairs	Pre-operatively			x	
	Post-operatively		x		
Ascending stairs	Pre-operatively			x	
	Post-operatively	x			
Rising from sitting	Pre -operatively			x	
	Post-operatively		x		
Standing	Pre -operatively			x	
	Post-operatively		x		
Putting on and taking off socks	Pre -operatively		x		
	Post-operatively	x			
Getting in/out of the bath	Pre -operatively			x	
	Post-operatively	x			
Getting on/off toilet	Pre -operatively			x	
	Post-operatively	x			
Going shopping	Pre -operatively			x	
	Post-operatively	x			
Bending	Pre -operatively			x	

	Post-operatively	x			
Sitting	Pre -operatively			x	
	Post-operatively		x		
Rising from bed	Pre -operatively			x	
	Post-operatively	x			
Heavy domestic	Pre -operatively			x	
	Post-operatively			x	
Light domestic	Pre -operatively	x			
	Post-operatively		x		

See Table 17 below for an indication of difficulty in certain activities still perceived by the patients pre- and post-operatively.

Table 17 – Summary of degree of difficulty and activity after completing the WOMAC

Degree of difficulty	Activity pre-operatively	Activity post-operatively
1 Slight/mild	Light domestic tasks	Ascending stairs Putting on and taking off socks Getting in/out of the bath Getting on/off toilet Going shopping Bending Rising from bed
2 Moderate	Putting on and taking off socks	Descending stairs Rising from sitting Standing Sitting Light domestic tasks
3 Very/severe	Descending stairs Ascending stairs Rising from sitting	Heavy domestic tasks

	Standing Getting in/out of the bath Getting on/off toilet Going shopping Sitting Rising from bed Heavy domestic	
4 Extremely		

- **Pre-operatively:** Descending stairs was marked by 26 (63.4%) participants as being very difficult and by 10 (24.39%) participants as being moderately difficult. Similarly, 21 (51.2%) participants indicated that ascending stairs were very difficult, and 14 (34.2%) participants indicated that they found it moderately difficult. Most of the participants indicated that rising from sitting (n=30, 73.2%), getting in/out of a car (n=32, 78.1%) were very difficult. Putting on socks (n=29, 70.7%) and taking off socks (n=30, 73.2%) were indicated by participants as being moderately difficult. Getting in/out of the bath (n=27, 65.9%) and getting on/off a toilet (n=27, 65.9%) were very difficult for participants. Going shopping (n=24, 58.5%) and standing (n=23, 56.1%) were also indicated as being very difficult by participants. Sitting proved to be very difficult for 26 (63.4%) participants and rising from a bed was difficult for 25 (60.9%) participants. Heavy domestic duties were indicated by 25 (60.9%) participants as being very difficult and 32 (78.1%) of participants indicated that light domestic duties proved to be slightly difficult.

- **Post-operatively:** Descending stairs was marked by 24 (77.4%) participants as being moderately difficult. Similarly, 18 (58.1%) participants indicated that ascending stairs were slightly difficult. Most of the participants indicated that rising from sitting (n=23, 74.2%) and standing (n=23, 74.2%) were moderately difficult. Putting on socks (n=28, 90.3%) and taking off socks (n=27, 90.0%) were indicated by participants as being slightly difficult. Getting in/out of the bath (n=22, 70.9%) and getting on/off a toilet (n=17, 54.8%) were slightly difficult for the participants. Going shopping (n=22, 70.9%) and bending (n=25, 80.7%) were indicated as slightly difficult by the participants. Sitting showed to be moderately difficult for 16 (51.6%) patients and rising from bed was slightly difficult for 21

(67.7%) patients. Heavy domestic duties were indicated by 12 (52.2%) patients as very difficult and light domestic duties were experienced by 23 (74.2%) patients as moderately difficult.

The average median score on the WOMAC for pre-operative evaluation (n=41) were 61.54 out of 96, where higher scores indicate worse pain, stiffness and functional limitations. The average median score on the WOMAC for the post-operative evaluation (n=31) was 36.46.

Stated differently, 36.46 out of 96, suggests a lower score in pain, stiffness and functional limitations. The change of the WOMAC score is a statistically significant, indicating that the patients achieved a better outcome post-operatively.

4.4 Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS) is generally used by clinicians as a screening tool to define the intensity of depression and anxiety in an individual (Brennan *et al*., 2010). Seven of the objects relate to depression and seven to anxiety.

To recap, the HADS has a total of 14 items, scored on a scale of 0 - 3 (where 3 indicates higher symptom frequencies). Scores for every subscale (anxiety and depression) range from 0 to 21, with scores characterized as follows: normal 0 – 7, mild 8 – 10, moderate 11 – 14 and severe 15 – 21. Scores for complete scales (emotional distress) range from 0 to 42, with higher scores representing more distress (Bjelland *et al.*, 2002). It is also available in other dialects. The standard scoring algorithm was used: anxiety score = sum of items 1*, 3*, 5*, 7, 9, 11*, 13*; and depression = sum of items 2, 4, 6*, 8*, 10*, 12, 14 where starred items are reverse scored. Both subscales have a possible range of 0–21, with higher scores indicating higher anxiety and/or depression.

In Table 18, the results are indicated for the pre- and post-operative evaluation:

Table 18 – Results for pre- (n=41) and post-operative (n=31) HADS

	Pre- operative	**Number of participants (n=41)**	**Post-operative**	**Number of participants (n=31)**
	0	2 (2.4%)	0	0 (0%)
	1	33 (80.5%)	1	1 (3.2%)

“I feel tense or ‘wound up’”	2	4 (9.8%)	2	22 (70.9%)
	3	2 (2.4%)	3	8 (25.8%)
“I still enjoy the things I used to enjoy”	0	4 (9.8%)	0	18 (58.1%)
	1	34 (82.9%)	1	13 (41.9%)
	2	3 (7.3%)	2	0 (0%)
	3	0 (0%)	3	0 (0%)
“I get a sort of frightened feeling as if something awful is about to happen”	0	11 (26.8%)	0	0 (0%)
	1	22 (53.7%)	1	0 (0%)
	2	4 (9.8%)	2	5 (16.1%)
	3	2 (2.4%)	3	25 (80.6%)
“I can laugh and see the funny side of things”	0	17 (41.5%)	0	18 (58.1%)
	1	1 (2.4%)	1	4 (12.9%)
	2	19 (46.3%)	2	9 (29%)
	3	1 (2.4%)	3	0 (0%)
“Worrying thoughts go through my mind”	0	4 (9.8%)	0	0 (0%)
	1	30 (73.2%)	1	1 (3.2%)
	2	6 (14.6%)	2	17 (54.8%)
	3	0 (0%)	3	13 (41.9%)
“I feel Cheerful”	0	14 (34.1%)	0	0 (0%)
	1	25 (60.9%)	1	1 (3.2%)
	2	2 (2.4%)	2	12 (38.7%)
	3	0 (0%)	3	17 (54.8%)
“I can sit at ease and feel relaxed”	0	4 (9.8%)	0	15 (48.4%)
	1	30 (73.2%)	1	16 (51.6%)
	2	7 (17.1%)	0	0 (0%)
	3	0 (0%)	0	0 (0%)
“I feel as if I am slowed down.”	0	0 (0%)	0	0 (0%)
	1	11 (26.8%)	1	6 (19.4%)
	2	28 (68.3%)	2	24 (77.4%)
	3	1 (2.4%)	3	0 (0%)
“I get a sort of frightened feeling like ‘butterflies in the stomach’”	0	3 (7.3%)	0	25 (80.6%)
	1	24 (58.5%)	1	4 (12.9%)
	2	11 (26.8%)	2	0 (0%)
	3	1 (2.4%)	3	0 (0%)
“I have lost interest in my appearance”	0	33 (80.5%)	0	0 (0%)
	1	1 (2.4%)	1	0 (0%)
	2	0 (0%)	2	0 (0%)
	3	7 (17.1%)	3	31 (100%)
	0	2 (2.4%)	0	1 (3.2%)
	1	15 (36.6%)	1	18 (58.1%)

"I feel restless as I have to be on the move"	2	24 (58.5%)	2	18 (58.1%)
	3	0 (0%)	3	10 (32.3%)
"I look forward with enjoyment to things"	0	7 (17.1%)	0	14 (45.2%)
	1	4 (9.8%)	1	5 (16.1%)
	2	30 (73.2%)	2	11 (35.5%)
	3	0 (0%)	3	0 (0%)
"I get sudden feelings of panic"	0	23 (56.1%)	0	0 (0%)
	1	16 (39.0%)	1	0 (0%)
	2	1 (2.4%)	2	0 (0%)
	3	0 (0%)	3	31 (100%)
"I can enjoy a good book or radio or TV program"	0	10 (24.4%)	0	16 (51.6%)
	1	28 (68.3%)	1	15 (48.4%)
	2	3 (7.3%)	2	0 (0%)
	3	0 (0%)	3	0 (0%)

In answering, if you feel tense or 'wound up', 33 (80.5%) participants answered, "from time to time, occasionally", while 34 (82.9%) participants indicated that they did not enjoy things quite as much.

Twenty-two (56.4%) participants answered that they got a little frightened, but 17 (44.7%) of participants indicated that they could still laugh and see the funny side of things.

Thirty (75.0%) participants indicated that they had worrying thoughts going through their minds from time to time, but 25 (60.9%) participants described that they were still cheerful.

Thirty (73.2%) participants indicated that they could usually sit at ease and feel relaxed, whereas 28 (70.0%) participants felt that they were very often slowed down.

Twenty-four (61.5%) participants answered that they occasionally experienced "butterflies in their stomach", while 24 (58.5%) participants indicated that they felt restless and had to be on the move quite a lot.

Thirty-three (80.5%) participants indicated that they took as much care as ever in their appearance, while 30 (73.2%) participants indicated that they definitely looked less forward to enjoyment of things.

Twenty-three (57.5%) participants indicated that they did not get a sudden feeling of panic at all. Twenty-eight (68.3%) participants indicated that they could sometimes enjoy a good book or radio or TV program.

An indication of 21 (51.2%) participants with mild depression was seen in the results of the study. In Figure 3 and Figure 4, the results can be seen of an indication of anxiety and depression in participants pre- and post-operatively.

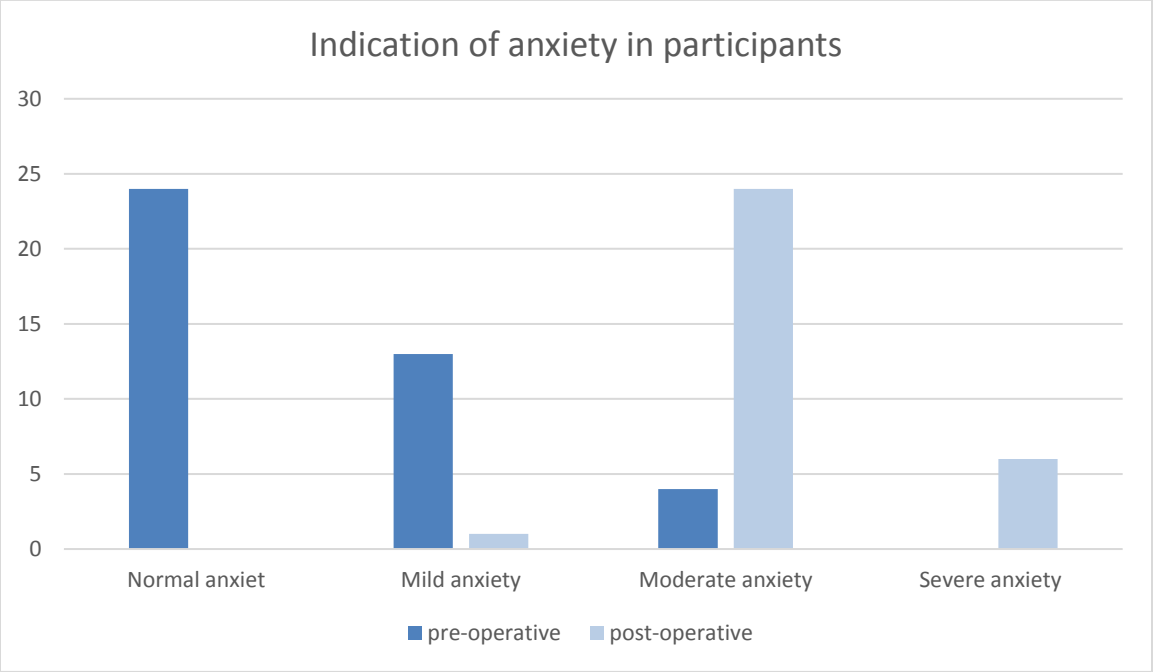

Figure 3 – Indication of Anxiety in participants as measured by HADS

The results showed that 24 (58.5%) participants experienced normal anxiety and 13 (31.7%) participants' mild anxiety pre-operatively. Post-operatively, 24 participants showed moderate anxiety and 6 participants severe anxiety.

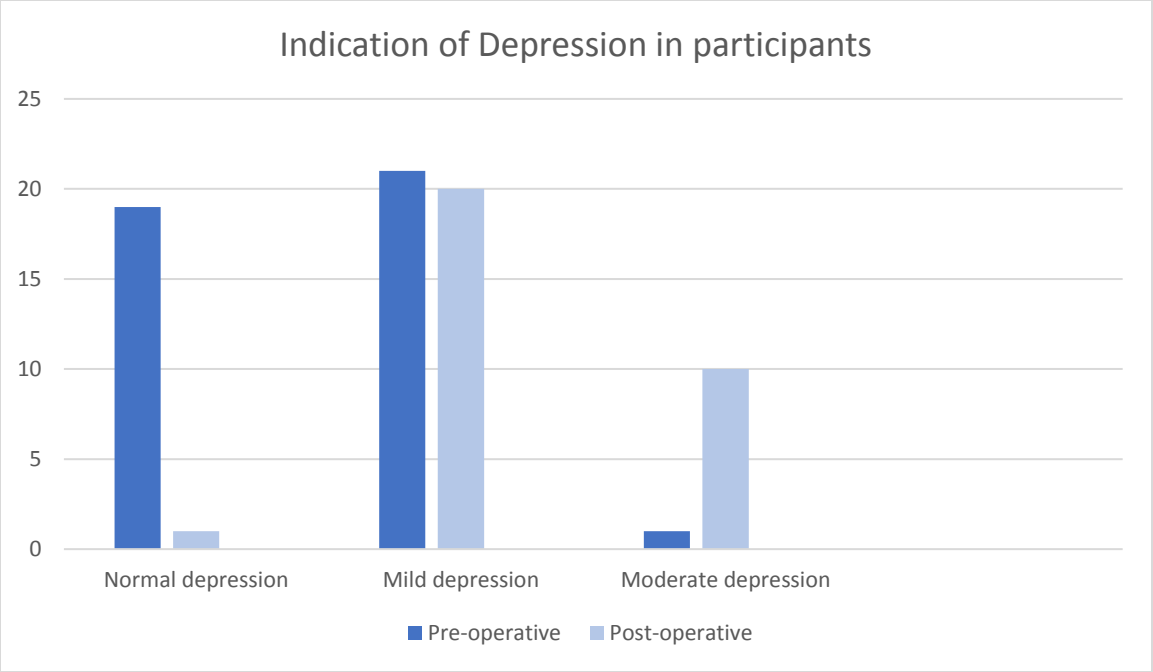

Figure 4 – Indication of depression in participants as measured by HADS pre- and postoperatively

In Figure 4, it can be seen that 19 participants resorted under “normal” depression and 21 participants under “mild” depression. Interestingly, post-operatively, 20 participants had “mild” depression and 10 participants had “moderate” depression.

Table 19 – Total HADS score indicating the median difference, IQR and statistical significance between pre- and postoperative measures

HADS	**Change (pre (n=41) – post (n=31) - operatively)**		
	Median	IQR	*Signed Rank test*
Anxiety	6 (14.6%)	4; 8	***p<0.01****
Depression	2 (2.4%)	0; 5	***p<0.01****

*Statistically significant

There was a statistically significant change for anxiety and depression between pre-operatively and post-operatively in participants.

From the results presented, it can be seen that patients are more anxious and depressed, as compared to pre-operatively.

4.5 Medical Outcome Study 36-Item Short Form Health Survey (SF-36)

The Medical Outcomes Study 36-item Short Form Health Survey (SF-36) is a general survey on health status and Health-Related Quality of life (HRQoL). It documents the calculation of a particular scale for each of the eight dimensions. The total varies from 0 to 100, where 100 shows optimal HRQoL.

The SF-36 is a patient-reported evaluation of patient health. The researcher used only a section of the SF-36. One of the main reasons was to not overload the patient with questionnaires and questions already asked in the previous questionnaires The researcher used question one, six, nine and ten of the SF-36, where the other questions were aimed at pain and function. Pain and function were already explored in this study with the BPI and WOMAC questionnaires.

Table 20 – Results of the pre- (n=41) and post-operative (n=31) SF 36 evaluation

Question	**Pre- operatively**	**Number of participants (n=41)**	**Post- operatively (6 weeks)**	**Number of participants (n=31)**
Cut down on the amount of time you spent on work or other activities.				
	1 - Yes	39 (95.1%)	1	31 (100%)
	2 - No	2 (2.4%)	2	0 (0%)
Accomplished less than you would like.				
	1 - Yes	40 (97.6%)	1	31 (100%)
	2 - No	1 (2.4%)	2	0 (0%)
Didn't do work or other activities as carefully as usual				
	1 - Yes	40 (97.6%)	1	30
	2 - No	1 (2.4%)	2	0 (0%)
During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours or groups? 1 *Not at all* *3 Moderately* *4 Quite a bit*				
	1	6 (14.6%)	1	0 (0%)
	3	25 (60.9%)	2	6 (19.4%)

	4	9 (21.9%)	3	25 (80.6%)
How did you feel and how have things been with you during the past 4 weeks? *1 All of the time* *2 Most of the time* *3 A good bit of the time* *4 Some of the time* *5 A little of the time* *6 None of the time*				
Did you feel full of pep?	2	2 (2.4%)	2	0 (0%)
	3	1 (2.4%)	3	0 (0%)
	4	13 (31.7%)	4	1 (3.2%)
	5	23 (56.1%)	5	21 (67.7%)
	6	2 (2.4%)	6	9 (29.0%)
Have you been a very nervous person?	3	3 (7.3%)	3	0 (0%)
	4	5 (12.2%)	4	0 (0%)
	5	29 (70.7%)	5	21 (67.7%)
	6	4 (9.8%)	6	10 (32.3%)
Have you felt so down in the dumps that nothing could cheer you up?	1	1 (2.4%)	1	0 (0%)
	2	1 (2.4%)	2	0 (0%)
	4	3 (7.3%)	3	0 (0%)
	5	5 (12.2%)	5	1 (3.2%)
	6	31 (75.6%)	6	30 (96.8%)
Have you felt calm and peaceful?	1	5 (12.2%)	1	1 (3.2%)
	2	27 (65.9%)	2	30 (96.8%)
	3	2 (2.4%)	3	0 (0%)
	4	2 (2.4%)	4	0 (0%)
	5	5 (12.2%)	5	0 (0%)
Did you have a lot of energy?	1	2 (2.4%)	1	0 (0%)
	2	5 (12.2%)	2	20 (64.5%)
	3	13 (31.7%)	3	5 (16.1%)
	4	17 (41.5%)	4	3 (9.7%)
	5	2 (2.4%)	5	2 (6.5%)
Have you felt downhearted and blue?	2	2 (2.4%)	2	0 (0%)
	3	2 (2.4%)	3	0 (0%)
	4	13 (31.7%)	4	2 (6.5%)
	5	21 (51.2%))	5	15 (48.4%)
	6	3 (7.3%)	6	14 (45.2%
Did you feel worn out?	2	3 (7.3%)	2	0 (0%)
	3	7 (17.1%)	3	0 (0%)

	4	21 (51.2%)	4	5 (16.1%)
	5	8 (19.5%)	5	26 (83.9%)
	6	2 (2.4%)	6	0 (0%)
Have you been a happy person?	1	4 (9.8%)	1	3 (9.7%)
	2	23 (56.1%)	2	26 (83.9%)
	3	4 (9.8%)	3	1 (3.2%)
	4	8 (19.5%)	4	1 (3.2%)
	5	2 (2.4%)	5	0 (0%)
Did you feel tired?	2	5 (12.2%)	2	0 (0%)
	3	6 (14.6%)	3	1 (3.2%)
	4	22 (53.7%)	4	4 (12.9%)
	5	7 (17.1%)	5	23 (74.2%)
	6	1 (2.4%)	6	1 (3.2%)
During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives)? *1 All of the time* *2 Most of the time* *3 Some of the time* *4 A little of the time* *5 None of the time*				
	2	30 (73.2%)	2	16 (51.6%)
	3	5 (12.2%)	3	11 (35.5%)
	4	5 (12.2%)	4	3 (9.7%)
	5	1 (2.4%)	5	0 (0%)

There was no significant change in the post-operative results of the participants. However, there was a clear indication that 39 (95.1%) participants pre-operatively and 31 (100%) post-operatively, had to cut down on the amount of time they spent on work or other activities and that they accomplished less than they would like to, past the past four weeks, as a result of emotional problems.

Twenty-five participants (60.9%) indicated pre-operatively and six (19.4%) post-operatively that during the past four weeks, their physical health or emotional problems interfered with their normal social activities (family, friends etc.), moderately.

Nine patients (21.9%) indicated pre-operatively that their problems interfered quite a bit with their life. Twenty-three participants (56.1%) indicated pre-operatively that they felt full of pep a little of the time during the past few weeks.

Twenty-nine (70,7%) participants indicated pre-operatively that they felt a bit nervous during the past four weeks, but 31 (75.6%) participants (pre-operatively) did not feel so down in the dumps that nothing could cheer them up.

Most of the 27 (65.9%) participants indicated (pre-operatively), that they felt calm and peaceful most of the time during the past four weeks. Seventeen (43.6%) participants indicated (pre-operatively) that they had a lot of energy some of the time and 21 (51.2%) participants indicated (pre-operatively) that they felt worn out some of the time.

Thirty (73.2%) participants indicated pre-operatively that their physical health or emotional problems influenced their time during social activities (like visiting friends, relatives etc.) most of the time.

No associations could be made between levels of pain experienced, functional ability, HRQoL and BMI due to the small group of participants.

In the next chapter, the results of the study will be discussed and compared to available literature.

5. Discussion

The discussion will explore all results found in the current study and relate it to results of previous and similar studies. The demographic information of the participants is comparable to the demographics of the population of the Free State, where the study took place. The pain and functionality of the participants before and after the TKA will be discussed and compared to published literature.

5.1 Demographic data

The median age of the participants of the current study was 65 years (Table 1, p64). The age profile of individuals receiving total knee replacements in a study conducted by Razak *et al*. (2016), indicated that the mean age of their 3 062 patients in an Asian population was 66.4 years and according to Bager *et al*. (2019), the prevalence of TKR's increased from 50-54 years until the age of 90-94 years in a Danish population. Unfortunately, the study did not indicate the mean or median age value of the participants. A study conducted by Power *et al*, (2019) on 360 total knee replacement patients in Canada indicated that the mean age was 65.1 years - which is similar to the current study.

The majority of the participants were female and Afrikaans speaking (Table 1, p64). It was expected that more females would have received a TKR, as the literature indicates that the ratio female-to-male for TKR in Germany was 2:1 (Rothbauer *et al*., 2018), while a study conducted in Nigeria in a resource-constrained environment in 2016 indicated that the ratio female to male was 4.4 to 1 (Anyaehie and Eyichukwu, 2017). More females than males also received a TKA in the study of Power *et al*. (2019), with 206 of the 360 participants being female. No specific information regarding the female-to-male ratio of TKR in South Africa could be found. Regarding the language most spoken by participants, according to the South African Gateway webpage of 2021, 13 % of the Free State population were Afrikaans speaking (*South Africa Gateway*, 2018). It was therefore expected that most of the participants in the current study were Afrikaans speaking. No specific statistics relating to the most spoken language in the Free State Province could be found. The participants indicated that they were either married of were staying with family.

The main diagnosis was osteoarthritis (OA) (Table 1, p64) and the median duration of symptoms were two and a half years. Noted from this data was that some of the participants also had other joint(s) with osteoarthritis. According to the literature, OA is the most prevalent underlying condition resulting in a TKA (Jacobs *et al*., 2021; Davies *et al*., 2019; Singh, 2011; Bleβ *et al*.,

2007). No literature could be found pertaining to the duration of symptoms experienced by individuals before a TKR. The majority of the participants did not use a walking aid and were living with hypertension. Interestingly, 95.1 % of the participants were smokers. This is slightly more than the participants in the Power *et al*. (2019) study who either were smoking at the time of the study (10.2) or formerly smoked (10.6). This included male and female participants. This data from the current study correlates with data found by Sullivan *et al*. (2011), stating that hypertension, tobacco use, and diabetes mellitus were some of the comorbidities that could affect TKR results.

According to Singh (2011), smoking puts an individual at great risk for mortality and post-operative complications following a TKA. Toxic components (carbon monoxide, nicotine and hydrogen cyanide) affect wound healing. Ischemia of the tissues is caused by Nicotine, reducing nutritional blood flow to the skin, which leads to impaired healing. Nicotine increases platelet adhesiveness and decreases the amount of red blood cells, thus increasing the risk of thrombotic microvascular occlusion. Transportation of oxygen to the cells are inhibited by hydrogen cyanide and a similar diminishing metabolism effect is caused by carbon monoxide (Carrothers Orthopaedics (2021).

Hypertensive patients had a higher risk of prolonged wound discharge and healing after an arthroplasty and are at greater risk for infection (Ahmed et al., 2011).

According to Statistics SA's Selected Health indicators amongst the elderly (2016), 63.1% of the elderly population in the Free State are living with hypertension. Differentials by place of residence in the report indicate that the elderly living in urban areas are more likely to live with hypertension (58.2%), as opposed to individuals living in non-urban areas (46.7%). Furthermore, the results of the report indicate that hypertension was more prevalent among elderly females (56,7%), compared to elderly males (48.9%) (*Statistics South Africa publications*, 2016). The study of Power *et al*. (2019) states that 45.8% of the participants in the study (male and female) indicated that they were living with one comorbidity (no indication was provided of the type of comorbidity) and 54.2% of the participants indicated that they were living with two or more comorbidities. This is a clear indication that most participants undergoing a TKA were already living with a comorbidity.

The highest education level was high school for most of the participants (Table 1, p65). This finding was to be expected, as according to Stats SA, Secondary school completion rate (age 25 and older) was 30.7% for SA (*Statistics South Africa*, 2021). Most of the participants (67.8%) in the study of Power *et al*. (2019) was educated at high school level or higher. No further details

were provided. This is higher than the education level of the current study - which is to be expected as Canada where the study of Power *et al*. (2019), was conducted is viewed as a developed country and SA as a developing country. The significance of education was studied by Rehkoph *et al.* (2006), who found that higher levels of education successfully completed were associated with better health, and better outcomes after surgery.

Income, socio-economic status and education can be possible reasons for patient outcomes. Mentioned in a study by Bendich *et al*. (2020) that socio-economic factors (income level and education) and demographic influences have an influence on their willingness to have a total joint arthroplasty. Hawker *et al*. (2002) concluded in their study that if taking willingness into consideration, individuals with less education and/or lower income were more likely to have a potential unmet need for arthroplasty. Also, in the last-mentioned study, individuals with lower SES had a greater need for an arthroplasty and equally willing as individuals in a higher SES. Skinner *et al*. (2006) concluded that lower-income individuals in certain continents (Africa and the USA in North America), have less access to care and would less likely have a TKA, whereas countries like Australia and Canada give their citizens a better chance to a well-established Health Care system. Higher SES individuals in the USA (Feldman *et al*., 2015), achieve greater functional outcomes and lower levels of pain after a TKA.

The significance of health education lies within the fact that the patient would know what to expect and have the knowledge of the process to decrease anxiety/questions - which in turn could decrease port-operative persistent pain.

In the current study, participants received more right-sided arthroplasties (53.7%), which is higher than a previous research study conducted in Greece (Andrianakos *et al*., 2006) and the Framingham Osteoarthritis Study (D'Ambrosia, 2005) performed in Asian and European populations. The latter study shows that OA is found more often in the right knee (23%) than in the left knee (16.3%) in males between the ages of 60-64 years, while OA in females is more evenly distributed with 24.4% in the right knee and 24.7% in the left knee. In addition, 32 of the 41 participants were first-time, elective knee arthroplasty patients (on the specific leg). According to anecdotal evidence from an orthopaedic surgeon (April 2017), if a patient is living with severe bilateral knee osteoarthritis, the choice of surgery for a TKR would be to firstly replace the dominant knee of the patient to ensure that the recovery of the opposite knee is made easier, as the dominant knee would primarily absorb the load of functional activities during the recovery

period. The dominance of participants in the study was not determined and could also have played a role in the side that more knee replacements were performed on.

5.2 Pre-operative and post-operative clinical evaluation

Obesity is a major health issue worldwide and a modifiable risk factor for individuals living with knee osteoarthritis (OA) (Blagojevic *et al*., 2010; Ogden *et al*., 2010). Pre-operatively, the body weight of the participants was between 75 and 102 kg (Table 2, p66) and their height between 1.59 and 1.77 m. The BMI range was between 28 and 36. According to the World Health Organization classification, the range for being overweight is between 25 and 29.0 and obese ≥30 (obese class I 30.0 – 34.9 and obese class II 35.0 – 39.9). As can be seen from the results, the participants in this study were mainly overweight and obese. Reasons for the increased BMI could be that the pain that they experienced decreased their functionality and their ability to exercise. According to Statistics SA's Selected Health indicators among the elderly (2016), it is indicated that 13,8% of elderly females in South Africa are either overweight or obese. For Reibe *et al.* (2009), obesity is associated with lower levels of physical activity and physical function. The findings of the current study are in line with other studies, as the study of Power *et al*., (2019) also indicated that most of the participants in the study were either overweight (34.2%) or obese (48.6%). The mean BMI of the participants in the study of Power *et al*. (2019) was 30.7 and in the current study 31, which is comparable.

A shortcoming of the study was that the researcher could not determine the BMI post-operatively due to logistical reasons. Anecdotal evidence indicates that patients either loses weight due to pain (loses appetite), feeling "down" and the effects of anaesthetics or they gain weight due to decreased mobility and function. From the literature, it seems that the relationship between pain and depression is complex and that depression is often viewed as the moderator between pain and physical functioning (Vadivelu *et al*., 2017).

Previous studies on overweight and obese individuals living with knee OA conducted in controlled and community-based environments found that a 10% weight loss resulted in decreased pain, improved function and improved HRQoL as well as lower inflammation levels and a decrease in loads on the knee joint compared to the individuals that lost less than 10% weight or did not lose weight at all (Atukorala *et al*., 2016; Messier *et al*., 2013).

According to a study conducted by Messier *et al*. (2019), long-term weight loss of between 10 and 19% of body weight of the individual did not only have good clinical but also mechanistic benefits compared to less weight lost by the individual. The value of an additional 10% provided significant improved physical activity, health-related quality of life (HRQoL) and decreased pain.

It is advised by Roche *et al*. (2018) that orthopaedic surgeons and health care professionals counsel patients to optimise their weight as part of pre-operative standard care before a TKA (Roche *et al*., 2018).

Knee flexion and extension were measured pre- and post-operatively. The median range for knee flexion was 113.33° pre-operatively and 98.33° post-operatively. The decrease in knee flexion after surgery could be attributed to oedema, pain sensitivity over the scar, soft tissue damage (Tai *et al.*, 2012) due to surgery and/or poor adherence to rehabilitation (Shakespeare *et al*., 2006). No more recent evidence could be found to substantiate a decrease in knee flexion as observed in the current study.

Knee extension had a median of 1.66° pre-operatively and 0° post-operatively. Knee extension clinically is more problematic for patients due to oedema (Holm *et al.*, 2010), a contracture of the Hamstring muscle group, pain during weight-bearing due to a decreased joint space and decreased muscle strength of the Quadriceps muscle group (McGinn *et al*., 2018; Christiansen, 2015). According to Holm *et al*., (2010) it is not uncommon for the knee after a TKA to have a 10° lag deficiency post-operatively due to oedema.

Whether participants experienced challenges with oedema of the knee was also explored in the pre- and post-operative questionnaires.

Of the 38 participants, 37 (97.37%) participants indicated that they experienced oedema of the knee. The median measurement of the left knee was 43 cm and 42 cm for the right knee. The oedema experienced pre-operatively forms part of the clinical features of knee osteoarthritis and therefore an expected finding in the study (Ralson *et al*., 2018). Post-operatively, the median measurement of the left knee was 45 cm (n=22) and of the right knee 43 cm (n=19). The increase in the oedema of the knee could be attributed to the surgery (incision as well as soft tissue initial changes after the surgery) and the physiological process of healing (Holm *et al*., 2010). Most of the TKA studies compare the affected and unaffected knee (Loyd et al., 2019) when measuring oedema. In addition, the decreased mobility of the joint regarding movements and the decreased

functional mobility of the participant could also contribute to the increased oedema (McGinn *et al*., 2018; Christiansen, 2015, Holm *et al*., 2010) and is a normal occurrence after surgery.

The physiological process of healing and the different stages should also be kept in mind (Holm et al., 2010). A timeline for Knee Replacement Surgery Recovery according to Bozic (2018), states that most patients can care for themselves and resume normal daily activities within six weeks and drive within three to six weeks. It may take four to six months or up to an entire year to fully recover and realize total benefits of knee replacement surgery. Clinically, the researcher observed that the knee will feel warm for the patient, which is a normal physiological process, but also that the patient may complain of swelling for up to three months and report more normal functional activity on a year post-operatively.

Participants were asked to indicate if they had difficulty navigating stairs (Fig 1, p67). They had to indicate whether ascending, descending or if both were difficult to perform. Descending stairs were more problematic for participants pre- and post-operatively. This could be attributed to decreased muscle strength, oedema, and decreased range of knee flexion (McGinn *et al*., 2018; Christiansen, 2015, Holm *et al*., 2010). The change from pre-operatively to post-operatively was statistically significant, which indicates that patients found it easier to climb stairs post-operatively as compared to pre-operatively.

It could be hypothesised that the mechanical deficit in the joint that restricted joint movement was removed during the surgery and that most participants found it easier after surgery to execute the functional activity and that the strength of the m Quadriceps muscle before surgery also influenced the stair-climbing ability of the patients. It is well established in literature that preoperative weakness of the m Quadriceps may continue after a TKA and has major implications on the movement patterns of the knee (Witchelo *et al*., 2013; Lin *et al*., 2010; Mizner *et a*l., 2005; Mizner *et al*., 2005; Mizner *et al*., 2005). The TKA procedure could further contribute to the m Quadriceps weakness (Saleh *et al*., 2010). It is also stated that the imbalance of the m Quadriceps with weakness of the m Vastus Medialis and an increase in the activation of the m Vastus Lateralis can cause a deviation in the tracking of the patella (Kohl *et al*., 2011; Chester *et al*., 2008). Deviation in the tracking of the patella can lead to pain or discomfort when using stairs, sitting to standing, sitting for long periods of time, jumping or kneeling (*physio.co.uk*, 2021).

It is well established that a TKA decreases pain and improves self-reported function, but according to Thomas *et al*. (2012), m Quadriceps strength does not recover to the levels of healthy age-matched individuals - even years after surgery. M Quadriceps muscle weakness leads to

functional consequences for the individual and is associated with a decrease in balance (Moxley *et al*., 1999); decreased gait speed (Brown *et al*., 1995) and stair climbing (Mizner *et al*., 2005) and difficulty rising from a chair (Skelton *et al*., 1994). More recent evidence regarding m Quadriceps weakness and functional consequences was not available.

Unfortunately, in the current study the researcher did not determine the pre-operative and post-operative m Quadricep's strength and therefore it is not possible to indicate whether the ability to navigate stairs easier was due to improvement in muscle strength or due to the mechanical deficit in the joint that restricted movement, which was removed.

With the evaluation of knee alignment pre-operatively (Table 4 p 69), it was seen that 22 patients presented with a normal knee alignment; 14 with Genu Valgum; and two with Genu Varus. Osteoarthritis progression in response to pathological reactions may be attributed to the effects of biomechanical forces. All these factors can lead to weakening of joint structures and aggravation of knee symptoms, with a resultant decrease of knee joint function and changes in knee alignment (Heidari, 2011).

Post-operatively, the participants in the currently study mostly presented with normal alignment due to the arthroplasty and surgical techniques, but the participants still complained of pain - mostly medially due to soft tissue, joint alignment, oedema and muscle imbalances, which was also found in studies performed by Holm *et al*. (2010), McGinn *et al*. (2018) and Christiansen (2015).

The onset of knee pain in this study was 42 years (longest) and three months (shortest). Some of the participants described that they had a sports injury, fell accidentally either recently or previously in their younger years, but walked and lived with the pain. According to the literature, clinical evidence of a traumatic injury or trauma to either the menisci, bone or ligaments may lead to an acceleration of OA development (Louboutin *et al*., 2009; Hunter *et al*., 2006; Burr, 2004) leading to pain, decreased range of motion and decreased function.

The most painful movement indicated by participants, pre- and post-operatively, was sitting. Knee flexion, however, produced the most familiar pain that participants complained of pre-operatively. According to a recent publication, dissatisfaction, and decreased quality of life after a TKA is often association with post-surgical anterior knee pain (Laubach *et al*., 2020). Currently, the underlying pathological mechanisms are not yet understood, so a multifactorial approach is

needed to address the challenge and further studies should investigate post-surgical anterior knee pain (Laubach *et al*., 2020).

Only one participant indicated that he/she had physiotherapy before his/her surgery (Table 6, p71). During their stay in hospital, 18 patients indicated they received physiotherapy management. The findings seem highly unlikely, as physiotherapy management is provided twice a day for patients during their hospital stay in the study setting, with the aim of improving their functional ability as much as possible before discharge. Possible reasons for the findings could be that participants were at radiology when they were supposed to receive physiotherapy management; that the participants did not consent to physiotherapy management due to pain; or that they already did their exercises on their own and indicated this as such to the attending physiotherapist.

Post-operatively, only 29 participants indicated they received physiotherapy management during discharge and the six-week follow-up. Routinely, many physiotherapy practices attending to arthroplasty patients attempt to consult with the patients once a week or once every two weeks for rehabilitation to improve outcomes. The aim of the sessions is to correct the gait pattern of the patient utilising the walking aid (often crutches), prevent stiffness of the knee joint, release muscle stiffness, decrease oedema and advise the patient regarding rehabilitation and strengthening exercises. It is unclear why the rest of the participants did not indicate that they received physiotherapy management after the TKA. Physiotherapy management before, during and after surgery is essential for better outcomes for the patient (*Atlantic Bone and Joint Centre*, 2016).

Physiotherapy treatment before (Table 6, p71), during and after surgery is deemed essential for ensuring better outcomes for patients after an arthroplasty (Hamilton *et al.,* 2020). A study conducted by Saw *et al*. (2016) on patients awaiting arthroplasty in public hospitals in SA indicated that a six-week physiotherapist-led exercise and health education intervention showed moderate effect size (ES) on pain severity at week 6: [$p<0.01$, ES=0.94,95%CI (0.45,1.41)] and moderate effects on pain interference at week 6: [$p<0.001$, ES=1.2, 95% CI (0.70,1.69)]. Fifty-three per cent of the participants in the study of Saw *et al*. (2016) indicated that the intervention improved their pain. Despite physiotherapy after a TKA is deemed essential, rehabilitation methods vary worldwide. Also, the utilisation of different methods has not been shown to deliver differences in patient outcomes (Hamilton *et al*., 2020). Not all patients have the means and the privilege to receive physiotherapy treatment before they receive surgery; however, Hamilton *et al*. (2020) clearly indicate that that there was no additional benefit to “an in-person” physiotherapy

rehabilitation compared to a home-based exercise programme for individuals before a TKA. However, a home-based exercise programme could benefit healthcare delivery and resource planning, especially in resource restricted environment such as South Africa (Hamilton *et al*., 2020).

In this study, there was no indication of participants receiving any medical intervention (p71) pre-operatively, which is to be expected as the choice of medical intervention is a TKR.

Post-operatively, 29 participants (p71) indicated that they did not need any other medical intervention after their surgery, except that that one participant indicated that he/she received anti-coagulants after a thrombosis. Receiving coagulants after a thrombosis is standard procedure as medical treatment (*Cleveland Clinic*, 2021).

Most of the participants received an information booklet (p71) from their surgeon before their surgery. The booklet mainly includes general information about the procedure and medical team, precautions, exercises and planned recovery. The physiotherapist must provide education regarding pain mechanisms, to prevent chronicity as this is usually not included in the surgeon's booklet. A study by Chen *et al*. (2014) also concluded that pre-operative health-education reduced the level of post-operative pain experienced by TKA patients, improved adherence to exercise and accelerated the recovery of their physical functioning. In the study by Chen *et.al*. (2014*)*, the pre-operative health education provided information regarding post-operative pain management; and assisted patients in developing accurate concepts of pain control to manage pain effectively rather than merely tolerate it. Controversy exists regarding the role of patient education before a TKA, and limited information is available. According to Eschalier *et al*. (2017), no consensus currently exists regarding the optimal content to be included in educational interventions before a TKA and the authors indicated that the educational booklet improves the knowledge of the patient regarding a TKA.

5.3 Brief pain Inventory

The pain severity of patients pre- and post-operatively was determined using a standardised questionnaire, the Brief pain Inventory. The participants were asked to indicate their highest minimum, average, and current pain intensity; list current management for their pain; their perceived efficiency of pain management; and rate how pain disrupted their overall activity,

attitude, ambulatory ability, standard work, and relationships with other people, sleep and pleasure of life on a ten-point scale.

In the current study, it is noticeable that most of the participants (31 out of 40) experienced their worst pain (Table 7, p72) as severe and their average pain as moderate pre-operatively. Pain also severely interfered with their general activity, mood, walking ability, normal work (including work outside and home and housework) and their relations with other people during the last 24 hours before completing the questionnaire pre-operatively. These findings indicated that the participants were never without pain.

In addition, the participants used a variety of Paracetamol and Non-steroidal ant-inflammatory drug (NSAIDS) for pain control pre-operatively providing most of them with only a 30% pain relief. The findings of the current study are similar to the findings of a study conducted by Lindberg *et al*. (2016) investigating how pre-operative pain intensity as well as pre-operative and peri-operative factors influenced the severity of acute average and worst pain after a TKA. The results of Lindberg's study found that co-morbidities, higher pain interference with function, older age and emotional responses to OA were all associated with higher pre-operative levels of pain. According to Kingsbury *et al*. (2013), it is not exactly known how many patients use medication before a joint replacement to relieve the pain, but it is estimated that nearly half of all OA patients use pain medication, often over-the-counter medication or prescription non-steroidal ant-inflammatory drugs and paracetamol.

Individuals living with OA often experience chronic pain, disability, depression and decreased quality of life (Jenkins *et al*., 2015; Murphy *et al*., (2012)). More than half of these individuals undergo a TKA to relieve pain and improve function (Rajamaki *et al*., (2019); Weinstein *et al*.,2013). Higher pre-operative pain levels (Lunn *et al*., 2013; Rakel *et al*., 2012) and opioid use have been identified as risk factors for increased pain after TKA in rest and during movement (Aasvang *et al*., 2016).

Most of the participants reported pain at more than one site (Table 8, p73). Individuals living with OA in one joint will often also experience OA in another joint or even joints, resulting in an increase in the symptomatic burden of the disease (Neogi, 2013). Pre-operatively, the most common site of pain was on the medial side of the knee joint (8); and post-operatively 14 participants indicated that they experienced pain on the medial side of the knee joint. The reason for the number of participants experiencing pain on the medial side of the knee joint could be due to most of the participants presenting with Genu Valgum and the anatomical loading on the medial structures.

According to Heidari, (2011), progression of OA may be attributed to the effects of biomechanical forces in response to pathological reactions. These pathological reactions can lead to progressive deterioration of the structures around the knee and can significantly worsen the knee symptoms - leading to a decrease in knee joint function. Malalignment (Varus or Valgus) has been found to be a risk factor for the progression of knee OA and increases the risk for medial and lateral OA respectively. Genu Valgum overloads the lateral compartment of the knee and stretches the medical collateral ligament, which can cause pain, knee instability and OA in patients.

TKA is a painful procedure and post-operative pain is not always well managed (Wylde *et al*., 2012). Post-operatively, 30 of the 31 patients still experienced pain. Most of the participants still experienced severe worst pain, and noteworthy was that more participants experienced severe average pain than pre-operatively. Participants indicated that pain interference with general activities were moderate and severe – 16 and 15 participants respectively; mild and moderate regarding mood – 11 and 17 respectively while seven participants experienced mild; 21 moderate and 3 severe interference during walking. Normal work interference due to pain was experienced as moderate by the majority of the participants, while 12 experienced mild and 17 moderate interference regarding relations with other people. Interesting was that 19 participants indicated that they experienced moderate interference with sleep and 11 mild interference with sleep.

TKA has a high prevalence of post-operative pain (Aasvang *et al*., 2015), which seems contradictory, as many patients undergo a TKA due to pain (Santaguida *et al*., 2008). A systematic review of post-operative pain performed by Ip *et al*. (2009) found that a younger patient, pre-operative pain as well as pre-operative anxiety and the surgical procedure were all predictors of post-operative pain. Research conducted by Bonnin *et al*. (2011) indicated that risk factors for poorer outcomes after a TKA included being female, younger, depression (higher than normal), anxiety and pain catastrophizing. Orthopaedic surgeons attempt to reduce the amount of pain experienced by patients after a TKA by among others, trying to reduce the tissue damage by shortening the length of the extensor apparatus incisions, modifying the type of arthrotomy and reducing the amount of unnecessary soft tissue release (Li *et al*., 2015). Different multimodal analgesic options (Chan *et al*., 2013; Chang *et al*., 2012) are also currently used in clinical practice to relieve pain, including paracetamol, nonsteroidal anti-inflammatory drugs (Adam *et al*., 2005), corticosteroids (Lunn *et al*., 2011).

All these strategies have advantages and disadvantages, both clinically and economically (Johnson *et al*., 2013; Bauer *et al*., 2012) and despite the fact that these approaches have

decreased the prevalence of persistent post-operative pain, further improvement in pain relief is necessary.

In addition to influencing the daily activities and mood of individuals, pain (Table 11, p76) also interfered with the sleeping habits of participants. One of the most frequently shared difficulties following surgery is difficulty sleeping, which has been associated with higher levels of pain and lower functioning (Creamens-Smith *et al*., 2006). The causes of difficulty sleeping may include cytokine release from the soft tissue injury; pain; stress due to the surgery; and medication (Hogan, 2015). The Creamens-Smith (2006) study proposed that improving sleep quality and reducing predominantly sleep disruptions with psychopharmacological interventions may decrease pain-related functional limitations. Sleep is a vital part of the healing process, as it contributes to the association between pain and functioning.

Clinically, if pain persists, it significantly interferes with a person's life, has been associated with functional limitations, depression, anxiety, sleep problems, poor general health, and possible long-term opioid use (Hassett *et al*., 2013; Wylde *et al*., 2011).

Treatment of pain after a TKA is challenging and often a combination of treatments or specific treatments to match the patient's characteristics is advocated. According to Wylde *et al*. (2018), to ensure that patients receive optimal care, the clinical effectiveness and cost-effectiveness of multidisciplinary interventions should be investigated.

5.4 Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is used to measure stiffness, physical function and pain in individuals with knee and/or hip osteoarthritis (OA). The sum of the three subscales gives a total WOMAC score out of 96. Higher scores on the WOMAC indicate worse pain, stiffness and functional limitations.

The average median score on the WOMAC for pre-operative evaluation (n=41) was 61.54 out of 96 (Table 12, p79), where higher scores indicate worse pain, stiffness and functional limitations. The average median score on the WOMAC for the post-operative evaluation (n=31) was 36.46 out of 96, which suggests a lower score in pain, stiffness and functional limitations.

Thus, in this study, there was an improvement on the pre-operative WOMAC score, which indicates decrease in pain, stiffness and an increase in ability of functional activities and is found statistically significant. Thus, showing an increase in functionality post-operatively for the participants.

No literature could be found to link the findings of the current study with similar studies, as most of the studies found described only WOMAC scores six months, a year or even longer after a TKA (Trieu *et al*., 2020; Power *et al*., 2019; Clement *et al*., 2018; Walker *et al*., 2018; Van der Wees *et al*., 2017) and not within the 6-week time frame of the current study. In addition, TKA: Minimal detectable change values and minimally clinically important difference after a TKA are only provided at six months and 12 months (Greco *et al*., 2010; Escobar *et al*., 2007).

Population normative values for the WOMAC are scarce and merely one article could be found after an extensive literature search (Bellamy *et al*., 2010). The values in the current study could unfortunately not be compared to the normative values, as the normative values determined by Bellamy *et al*., (2010) were calculated for healthy individuals and not for individuals with a TKA. To be expected, the WOMAC values for the TKA participants in the current study were higher than the norms in a healthy population.

The results of a systematic review reporting on clinical trials utilising the WOMAC as outcome measure for the pain of OA of the knee found that reporting of the WOMAC pain subscale and WOMAC index was poor in most studies included in the systematic review. The poor and inconsistent reporting of the WOMAC made interpretation of trial results extremely difficult and limited evidence. Adherence to the standard WOMAC scoring system, as well as clear and standardised reporting of the results, should be encouraged to enable comparison of research results when the WOMAC is utilised as outcome measure (Woolacott *et al*., 2012).

5.5. Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS) is generally used by clinicians to define the intensity of depression and anxiety in an individual. Seven of the objects relate to depression and seven to anxiety. The researcher wanted to investigate if anxiety and depression could play a role in the outcomes of the surgery. Most of the participants indicated that they felt tense and that they did not enjoy things quite as much.

A study conducted by Breeman *et al*., (2015) determined normative values for the HADS in a large population-based study in the United Kingdom. The scores were calculated completing all items on each sub-scale for 6 189 participants for the anxiety section and 6 198 participants for the depression section. Scores for the HADS were presented by gender and by five-year age groups. As the median age of the current study was 65 years, the normative values will be compared to the age group 60-65 years and only for females, as most of the participants in the current study were females.

In the age group of 60-65 years, 392 participants were included to determine the normative values for anxiety in the Breeman *et al*. (2015) study. The median value found in the Breeman *et al*. study (2015) was 6 with interquartile range (IQR) (3; 8). Pre-operatively, the score for anxiety for the current study was 7 (IQR 6;9), which is comparable to the Breeman *et al*. (2015) study. The anxiety score post-operatively was higher than anticipated and higher than the norms of the Breeman *et al*. (2015) study. Post-operatively, the anxiety score was 13 IQR (12;14).

The depression normative values in the Breeman *et al*. (2015) study was determined by utilising 399 participants. The median value was indicated as 3 with IQR (1;6). The results of the current study indicated that the median anxiety score for participants pre-operatively was 8 and the IQR (6;9), while the depression median score post-operatively was 9 and IQR (8;11), which was also higher than the normative values of the said Breeman study.

According to the literature, pre-operatively, the prevalence of depression and anxiety was high. The results of the studies indicated that post-operatively (3 and 12 months), the prevalence of depression and anxiety started to decrease in all arthroplasty patients. Mentioned by the authors is that patients with pre-operative depression and anxiety symptoms had worse reported self-reported outcomes and seemed to be less satisfied with the outcomes of the surgery than patients who did not experience anxiety and depression pre-operatively (Mahdi *et al*., 2021; Ditton *et al*., 2020; Duivenvoorden *et al*., 2013).

The change between pre- and post-operative for the participants in the current study regarding HADS anxiety and depression was also not aligned with the normative values as described by Breeman *et al*. (2015), although the difference was statistically significant. It could be hypothesised by the researcher that the patients in the current study were still experiencing some pain, swelling and even functional challenges, which might have led to the increased HADS anxiety and depression, as they did not expect the limitations to still be present after the TKA.

The regularly reported predictors of satisfaction after a TKA were improved and higher post-operative function, decreased pain and fulfillment of expectation of the patient were reported (Kahlenberg *et al*., 2018; Choi and Ra, 2016; Thambiah *et al*., 2015).

The current study showed an increase in anxiety and depression, which is contradictory to other studies, but of clinical importance, as it could potentially lead to chronic pain (chronic pain is considered as pain of more than three months). Pain provokes an emotional response in humans (Bruce, 2021) and the individual may become irritable, anxious, and agitated. Usually, as pain subsides, so does the stressful response. But with chronic pain, the individual might feel tense and stressed constantly. Over long periods of time, the stress can result in different emotional problems associated with depression or anxiety.

Depression and chronic pain share some of the same neurotransmitters and brain chemicals that act as messengers traveling between nerves and also share some of the same nerve pathways in the brain and spinal cord. The influence of chronic pain could lead to loss of income or a job, lack of exercise, sleep disturbances; and losses in social networks, relationships and sexual relations. These mentioned losses can increase depression in people who are susceptible to clinical depression, which then amplifies the pain and reduces the individual's ability to live with the pain (Bruce, 2021).

The results for the part of the SF-36 were aimed at supporting the HADS, showing the emotional/psychological side that is missed with patients.

5.6 Medical Outcome Study 36-Item Short Form Health Survey (SF-36)

Usually, research studies using outcome measures, in this instance the SF-36, report on the mean improvement in HRQoL of the individual at population level, which then ultimately provides information pertaining to the average patient in a specific population, in this instance TKA population (Singh *et al*., 2010). Yet, some of the individuals, in a clinical environment, will be more concerned with improvement in their pain and function. The meaningful change for the individual is called the minimal clinically important difference and is defined as "the minimal difference in scores of an outcome measure that is perceived by patients as beneficial or harmful" (King, 2011; Escobar *et al*., 2007; Jaeschke *et al.,* 1989). A related concept also used in articles is called minimal detectable change; both these concepts are more clinically orientated and focusses on

the patient (Escobar *et al*., 2007) In order to use any of the concepts as described above, the full SF-36 should be utilised to draw comparisons. Since the researcher in the current study used only a section of the SF-36 as previously mentioned, comparing the results of this study with similar studies is not possible.

One of the main reasons for not including the entire SF-36 was to prevent respondent fatigue, as certain questions have already been asked in the previous questionnaires. Respondent fatigue is a well-known and documented phenomenon in research that occurs when participants become overloaded and tired of completing questionnaires and performing tasks, which in the end then compromises the quality of the data (*Encyclopedia of Survey Research Methods*, 2011). This usually occurs when participants' motivation and attention drop towards the later section of a questionnaire. It is therefore essential that respondent fatigue should be considered when deciding upon the number of questionnaires and the length of questionnaires during research - especially in real life scenarios where patients pre-operatively have divided attention between orthopaedic surgeons, nursing staff and researcher. The results for the part of the SF-36 were aimed at supporting the HADS, showing the emotional/psychological side that is often missed with patients.

In summary: There were statistically significant improvements in oedema of the knee, knee extension, average pain experienced daily, pain relief with medication, enjoyment of life, relations with other people, normal work ability, walking ability, mood, total WOMAC score and subdivisions of the WOMAC and in the Hospital Anxiety and Depression Score (HADS – anxiety and depression)

No association could be made in the study between levels of pain, functional ability, functionality and HRQOL and BMI due to the combination options in the study being too few in a group to enable associations.

6. Conclusion

The study has described the characteristics of the 41 individuals who received an elective TKA in a private hospital in Bloemfontein. The study revealed that most of the individuals opting for a TKA were females, with a median age of 65 years who spoke Afrikaans. The main diagnosis for receiving a TKA was OA, and the median duration of symptoms were two and a half years. Most of the participants in the study were either overweight or obese and found navigating stairs difficult pre- and post-operatively. The importance of physiotherapy management pre-operatively and post-operatively is undeniable as most of the patients experience pain and decreased function that impacted their quality of life.

There were statistically significant improvements in: increased oedema of the knee, knee extension loss of range of movement and a higher anxiety and depression score. The increased oedema and loss in extension range could be as a result of the physiological healing response that takes place after surgery. An interesting observation is the increase in anxiety and depression, which is contradictory to the findings of other studies. It could be hypothesised that the participants felt anxious and depressed as their expectations regarding function were not met after the surgery (decreased mobility because of oedema and pain) and that they were not expecting as much discomfort after the surgery.

Specific recommendations for further research have been put forward as well as clinical recommendations. This is to improve not only the outcomes of a TKA, but also to create awareness among physiotherapist regarding the challenges that individuals experience after a TKA and the importance of appropriate and relevant pre-rehabilitation and post-rehabilitation.

6.1 LIMITATIONS AND RECOMMENDATIONS OF THE STUDY

The limitations noted during the study as well as possible recommendations will now be discussed.

Patient reported outcome measures have become an essential part of outcome measures utilized after TKA to assess the perceived functional improvement experienced by patients. According to literature as cited by Giesinger *et al*. (2015), relying only on changes pre- and post-operatively ignores the fact that many patients despite showing improvement after surgery may still experience pain and functional impairments.

The data from the current study should be interpreted with caution, as participant satisfaction - which is an important factor in outcomes after surgery, was not explored in this specific study. The regularly reported predictors of satisfaction after a TKA were improved and higher post-operative function, decreased pain and fulfillment of expectation of the patient (Kahlenberg *et al*., 2018; Choi and Ra, 2016; Thambiah *et al*., 2015). One of the challenges of assessing patient satisfaction is that there is no standardization of determining patient satisfaction (Kahlenberg *et al*., 2018). According to Hofmann *et al*. (2014), patient satisfaction may correlate with age, range of motion, functional status and it seems the most important factor being the fulfillment of the patient's expectations. A recommendation is that qualitative research be conducted to determine the patient's perspective of satisfaction and that professional societies (physiotherapy and orthopedic societies) promote the use of a satisfaction questionnaire to improve the outcome and experience of a TKA.

To make a meaningful comparison between the study and other TKA studies utilizing the SF-36, it would be advisable to include the entire SF-36 and not just certain sections of the SF-36. Although the intention of the researcher was to prevent participation fatigue, the decision ultimately prevented comparability of the results of the current study with that of available literature. The SF-36 questionnaire was chosen, as the questionnaire would address the objectives as set out for the research study.

In future, careful consideration should be given regarding the number of questionnaires to be included and the length of the questionnaire, yet still ensuring that the include questionnaires achieve the aim of the study.

A limitation of the current study was that baseline data was collected before the surgery and then again after six weeks' follow-up after the surgery. Therefore, a longitudinal study should rather have been conducted where participants are assessed again after three months, six months, a year or even two years to be able to compare the results of the current study with other published articles. This was unfortunately not possible in the current study, due to the logistics of patients adhering to follow-up dates and to the limited time frame to complete the master's degree.

To comment on the reason why participants in the current study found navigating stairs challenging, a limitation of the current study needs to be acknowledged in that m Quadriceps muscle strength was not included in the physical evaluation of the participants. Objective muscle testing utilising the Oxford scale should be included in future studies of this nature. According to Thomas and Stevens-Lapsley (2012), reducing central activation deficits (CAD) as soon as

possible after a TKA is essential to minimise the effect of m Quadriceps weakness and to effectively restore function. Future research should be performed to investigate and understand the mechanisms underlying m Quadriceps CAD after a TKA.

It is clear from the results that pain control and the effect pain, has an impact on the outcome of a TKA. Perioperative care before an arthroplasty should not be underestimated. A recommendation would be to implement pre-operative, video-based pain training for all patients undergoing an elective TKA. A non-randomized control group study conducted by Gündüz and Calişkan (2021) utilizing video-based pain training found that the intervention group's mean post-operative scores for pain were significantly lower compared to the control group and the intervention group's pain management was also better compared to the control group (p<0.5). The findings also indicated that the intervention group used significantly less paracetamol on the day of the surgery compared to the control group. Therefore, a recommendation is that a culturally acceptable pain video should be developed and provided to patients undergoing a TKA as a strategy to reduce post-operative pain. The video could potentially be developed by the pain interest group in SA via Delphi consensus. Orthopedic surgeons and physiotherapists can then be informed regarding the video for utilization in their practices when consulting with patients pre-operatively before a scheduled TKA.

Added benefits to video training according to Abed *et al*. (2014) is that patient can benefit from the video training at their own time, in the comfort of their home, at any rate they wish to watch the video; they can repeat the video as many times as they wish, and family and friends can be included in the training. The authors also stated that the training video can be used by patients with limited literacy, which is an added benefit in the SA context.

According to Escalier *et al*. (2017), an educational booklet improves the knowledge of the patient regarding a TKA, but the authors suggest that the impact of the booklet combined with an exercise programme should be investigated in future research. A recommendation that is supported by the researcher.

In conclusion, with a TKA it is extremely important that physiotherapist to look at the patient holistically, including the patient's pain, function, health, social aspects, psychological and physiological components. The focus of the managements should be person-centred to ensure not only ensure patient satisfaction, but also to improve the health-related quality of life of the patient.

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Appendices

Appendix I

Letter asking permission from Head of the Medi Clinic Bloemfontein Hospital

Mr Buhrmann

Approval for research study in Total Knee Arthroplasty (TKA) patients at Medi Clinic Bloemfontein

Study title: Pain, function and Health-related quality of life in Total Knee Arthroplasty

Physiotherapists manage patients with TKA daily and experience that certain patient do better in their rehabilitation than others. Some patients tend to get better out of bed, walk better with a walking aid and execute exercises better.

I am currently busy with my M.Sc. in physiotherapy at the University of the Free State. My interest is Orthopaedics and I would like to carry out an investigation to determine pain, health-related quality of life and functionality pre- and post-operatively in total knee replacement patients.

Total Knee Arthroplasty (TKA) is generally regarded as a highly successful procedure to correct deformities, improve pain and function. In the past years, the increasing requirements of the population have made this method, along with hip arthroplasty, the succeeding most prevalent orthopaedic operation and forthcoming approximations show that demands will raise in years to come.

Knee Osteoarthritis (OA), affects approximately six percent of the adult population in the United Kingdom, United States and Australia, and this proportion rises in people who are older than 55 years.
This study is going to aim to create data that can be used to inform patients pre-operatively of expected outcomes, based on pre-operative status, which may further help patients set realistic goals for improvement after TKA.

Patients with a high score on the pain catastrophizing scale pre-operatively also have a longer hospital stay after TKA (Witvrouw et al, 2009). The Witvrouw et al. study can be used as a

motivation by hospitals and medical aids to further investigate options to reduce hospital stay after TKA. A study by Scranton (2001) indicated that providing all TKA patients with pre-operative education resulted in an improved, more predictable recovery (Scranton, 2001). A research study by Chen et al., 2013, also determined that the pre-operative health-educational intervention reduced the level of post-operative pain experience by TKA patients, increased the regularity with which they performed rehabilitative exercises and accelerated the recovery of their physical functioning (Chen, Chen and Lin, 2014).

Age of participants, is also a forecaster of the length of hospital stay following TKA. Suggestions have been made by the authors that elder patients should receive special care to lessen the risk of lengthier hospitalisation.

The aim of the study is to determine the pain intensity, functionality and health-related quality of life pre- and post-operatively in persons undergoing total knee arthroplasty.
The objectives of the study (within the specific population is):

- To determine the individual's pain intensity at baseline pre-operatively and six-week post operatively using the Brief Pain Inventory (BPI)
- To determine the individual's functionality using the WOMAC
- To determine the individual's passive and active knee range of motion using a goniometer at baseline pre-operatively and six-week follow-up visit.
- To determine the individual's muscle strength of m Quadriceps and mm Hamstrings using the Oxford scale at baseline pre-operatively and six-week follow-up visit.
- To determine the BMI of the person at baseline and on the six-week follow-up visit.
- To determine the health-related quality of life of the individual by utilising the SF-36 baseline pre-operatively and six-week follow-up visit.
- To determine the anxiety and depression of the individual by utilising the HADS on the first visit pre-operatively and six-week follow-up visit.
- To determine the association between levels of pain, functional ability, functionality, HRQoL and BMI.

There will be no disruption to normal activities in the hospital due to the study.

An information session will be held with the Orthopaedic surgeon and relevant physiotherapists (working with the doctor's patients).

The results of the different questionnaires and the information of all the participants will be strictly confidential. All the partakers will have access to their own results and outcomes. The conclusion of the study will be communicated to the orthopaedic surgeons and the hospital management. The study could be presented at a meeting or congress or issued in an accredited journal.

This letter is requesting your approval to recruit patients planned for a Total Knee Arthroplasty from Medi Clinic Bloemfontein to take part in my study.

The protocol for this research will be submitted to the Health Sciences Research Ethics Committee of the University of the Free State for approval. The protocol of the research is obtainable from the secretary of the Health Sciences research Ethics Committee Ethics committee of the University of the Free State's Faculty of Health Science on request.

If any uncertainties arise regarding the study, you can reach me at 082 481 9240 or send me an email at hvdm2004@yahoo.com or contact my study leader, Dr Roline Barnes at BarnesRY@ufs.ac.za or contact the secretary of the Health Sciences Research Ethics Committee of the University of Free State at 051-4052812.

If permission is granted for recruitment of patients scheduled for a Total knee Arthroplasty from Medi Clinic Bloemfontein, please sign the attached slip.

Yours faithfully

Helena van de Wall

_____ (Signature and date)

(Researcher/Physiotherapist)

Appendix II

Letter asking permission from the Orthopaedic Surgeon Medi Clinic Bloemfontein Hospital

Doctor

Approval for research study in Total Knee Arthroplasty patients from your practice at Medi Clinic Bloemfontein

Study title: Pain, Health-related quality of life and functionality pre- and post-operatively in Total Knee Arthroplasty patients.

I am currently busy with my M.Sc. in physiotherapy at the University of the Free State. My interest is Orthopaedics and I would like to do an investigation to determine pain, health-related quality of life and functionality pre- and post-operatively of total knee replacements patients.

Total Knee Arthroplasty (TKA) is generally regarded as a highly successful procedure to correct deformities, improve pain and function. In the past years, the increasing requirements of the population have made this method, along with hip arthroplasty, the succeeding most prevalent orthopaedic operation and forthcoming approximations show that demands will raise in years to come.

Knee Osteoarthritis (OA), affects approximately six percent of the adult population in the United States, United Kingdom and Australia, and this percentage increases in people who are more than 55 years old. Primary OA progresses with age, while secondary arthritis is linked with primary joint diseases, growth disorders or injury. Factors inclining to secondary OA of the knee are female gender, excessive knee angle (valgus, varus), hereditary factors, overweight, trauma to the knee, heavy physical work and inflammatory joint diseases.

I want to investigate if it is possible to advise patients before their surgery of probable outcomes, based on pre-operative status, which may further assist patients to set realistic goals for improvement after TKA.

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) has been studied extensively and its scales have been shown to be reliable and valid for quantifying the extent of both pain and disability in patients undergoing TKA. The Brief Pain Inventory short form (BPIsf), a self-administered questionnaire, can be used to assess pain and the extent to which it interfered

with the patient's life. The Medical Outcomes Study 36-item Short Form Health Survey (SF-36) is a generic questionnaire on health status and Health-Related Quality of life (HRQoL), related to eight dimensions of health. The HADS (Hospital Anxiety and Depression Scale) was designed to provide a simple yet reliable tool for use in medical practise.

Patients with a high score on the pain catastrophizing scale pre-operatively also have a longer hospital stay after TKA (Witvrouw et al, 2009). The authors assume that patients with extraordinary pre-operative catastrophizing thinking will be likely to avoid physical activity and movements post-operatively. So, this behaviour will result in slower progress in functionality. The Witvrouw et al. study can be used as a motivation by hospitals and medical aids to further investigate options to reduce hospital stay after TKA. A study by Scranton (2001) revealed that if all TKA patients are provided with pre-operative education, it will help with an improved, more predictable recovery (Scranton, 2001). As cited by the researcher, the Cochrane study discovered a valuable effect of pre-operative education in decreasing pre-operative anxiety. A research study by Chen et al., 2013, also determined that the pre-operative health-educational intervention reduced the level of post-operative pain experience by TKA patients, increased the regularity with which they performed rehabilitative exercises and accelerated the recovery of their physical functioning (Chen, Chen and Lin, 2014).

Age of participants, is also a forecaster of the length of hospital stay following TKA. Suggestions have been made by the authors that elder patients should receive special care to lessen the risk of longer hospitalisation.

Physiotherapists work with TKA patients daily. One can't help to wonder why certain patients do better in their rehabilitation than others. Some patients tend to get better out of bed, functionally walk better with a walking aid and execute exercises better. Riddle et al., 2010 has performed a study investigating the psychological aspects that predict clinical outcomes in patients after undergoing a TKA. The authors found that pain catastrophizing increases the risk for poor outcomes in patients and also found that patients who received pain coping skills training before the surgery reported significant decrease in pain severity.

The aim of the study is to determine the pain intensity, functionality and health-related quality of life pre- and post-operatively in persons undergoing total knee arthroplasty

The objectives of the study (within the specific population is):

- To determine the individual's pain intensity at baseline pre-operatively and six-week post operatively using the Brief Pain Inventory (BPI)
- To determine the individual's functionality using the WOMAC
- To determine the individual's active and passive knee range of motion using a goniometer at baseline pre-operatively and six-week follow-up visit.
- To determine the individual's muscle strength of m Quadriceps and mm Hamstrings using the Oxford scale at baseline pre-operatively and six-week follow-up visit.
- To determine the BMI of the person at baseline and on the six-week follow-up visit.
- To determine the health-related quality of life of the individual by utilising the SF-36 baseline pre-operatively and six-week follow-up visit.
- To determine the anxiety and depression of the individual by utilising the HADS on the first visit pre-operatively and six-week follow-up visit.
- To determine the association between levels of pain, functional ability, functionality, HRQoL and BMI.

There will be no disruption to normal activities in the hospital or your practice due to the study.
An information session will be held with you and the relevant physiotherapists (working with your patients).
The researcher will explain the following:

The orthopaedic surgeon's role:

- that the surgeon must consider referring the individual eligible for the TKA pre-operatively for an assessment with the researcher and ask the individual if he/she will sign a consent form to be contacted by the researcher for possible inclusion in the research study
- request that the individual consult with the researcher before the patient consults with the surgeon for the six-week follow-up
- Some of the Orthopaedic surgeons, send the patients for a routine pre-operative evaluation with the treating physiotherapists

The results of the different questionnaires and the information of all the participants will be strictly confidential. All the partakers will have access to their own results and outcomes. The conclusion of the study will be communicated to the orthopaedic surgeons and the hospital management. The study could be presented at a meeting or congress or issued in an accredited journal.

This letter is requesting your approval to recruit patients planned for a Total Knee Arthroplasty from Medi Clinic Bloemfontein to take part in my study.

The protocol for this research will be submitted to the Health Sciences Research Ethics Committee of the University of the Free State for approval. The protocol of the research is obtainable from the secretary of the Health Sciences research Ethics Committee Ethics committee of the University of the Free State's Faculty of Health Science on request.

If any uncertainties arise regarding the study, you can reach me at 082 481 9240 or send me an email at hvdm2004@yahoo.com or contact my study leader, Dr Roline Barnes at BarnesRY@ufs.ac.za or contact the secretary of the Health Sciences Research Ethics Committee of the University of Free State at 051-4052812.

The letter is asking your permission to recruit patients scheduled for a total Knee Arthroplasty from your practice to participate in my study. The patient will receive or undergo a pre-operative assessment and a post-operative assessment on the six-week follow-up. There will be no extra costs for the patient. If the researcher identifies any complications or concerns for example swelling, the researcher will make use of the necessary referral systems to refer the patient to the appropriate health care professional (using the specialist's choice of health practice) for further management (physiotherapy, psychiatry etc.). This will be done on the first consultation and the six-week follow-up.

If permission is granted for recruitment of Total knee Arthroplasty patients from your practice, please sign the attached slip.

Yours faithfully

Helena van de Wall

(Researcher)(Physiotherapist)

CONSENT FOR RESEARCHER TO CONTACT THE PARTCIPANT

With this letter, I, Mr/Ms/Miss _____ give consent for the researcher, HG van de Wall, to contact me at _____ (number), to make an appointment for the evaluation of my knee and the completion of questionnaires for the research study.

I understand that the appointment will be at **no extra cost** for me and that the study is going to be used to improve future care for Total Knee Replacement patients. I understand that there will be no extra travelling costs and that I will receive no payment.

I also received an Information letter with this consent form.

_____ _____

Signature Date

Appendix III

An information letter and informed consent to obtain approval from the participant

Dear sir/madam

Title: Pain, Health-related Quality of life and functionality Pre- and Post-operatively in Total Knee Arthroplasty patients.

Researcher: Helena van de Wall

You have indicated your interest to participate in this study regarding pain, health-related quality of life and functionality, before and after your total joint replacement/ arthroplasty of your knee.

Health-related quality of life	General health - diabetes, hypertension, cancer etc. and how it impacts on your health status and your quality of life
Functionality	Routine activities that people tend to do every day without needing assistance)
Total joint replacement/ arthroplasty	Is the medical word used for a joint replacement of your knee
Pain	Is an unpleasant feeling or discomfort

I am currently busy with my M.Sc. in Physiotherapy at the University of the Free State (UFS). I am interested in determining how we can improve certain results to improve your experience.

The study and its procedures have been accepted by the Health Sciences Research Ethics Committee of the University of the Free State, the Head of Medi Clinic Bloemfontein and the relevant Orthopaedic surgeons.

The study involves completion of various questionnaires in the company of the researcher on a computer. The questionnaires will be completed on the first doctors' visit before the operation

and on the six-week follow-up with the surgeon. It will take approximately 45 minutes to complete the **questionnaires** and **evaluation** on each of the two occasions.

The **Questionnaires** that you are going to complete, will be asking questions about your pain, your general health status, you're every day and social activities and difficulties. The **evaluation** entails measuring of your weight, length, your movement and strength of your knee and if we can measure any swelling around your knee. Questions about possible other treatments and demographic information will be part of the questionnaires.

Potential benefits of this study could be the improvement of existing guidelines or programs to help you, the patient, to have better results and to answer your problematic questions better.

To take part in the study, you need to be electing for a total knee replacement at an Orthopaedic surgeon practising at Medi Clinic Bloemfontein.

There is no risk or danger taking part in this study. You have no responsibility to participate and it is voluntary. You can withdraw from the study at any time, without any penalty or consequence. You will get no payment for taking part in this study. The evaluation is viewed as standard procedure before the arthroplasty and forms part of the preparation of the procedure. The cost of the evaluation will be no more than the normal evaluation which serves as protocol for the surgery. You will get no payment for taking part in this study; **neither will you have to pay anything to take part in the study. ICPS candidates' cost is already calculated with their packages of the hospital and surgeon**. If the researcher identifies any complications or concerns for example swelling, the researcher will make use of the necessary referral systems to refer you to the appropriate health care professional (using the specialist's choice of health practice) for further management (physiotherapy, psychiatry etc.). This will be done on the first consultation and the six-week follow-up.

Permission has been asked from the Head of Medi Clinic Bloemfontein and the Orthopaedic surgeons. The study will be submitted to the Health Sciences Research Ethics Committee of the University of the Free State for authorization.

If any questions arise before or throughout your partaking in the study, you are welcome to contact the researcher, Helena van de Wall at hvdm2004@yahoo.com or 051-4445282, or the study

leader, Dr Roline Barnes at BarnesRY@ufs.ac.za. The secretary of the Health Sciences Research Ethics Committee of the University of the Free State can also be contacted at 051-4052812 if any queries rise as to your privileges as a participant in the research.

All your information and results will be strictly private. If requested, you will have access to your own results. Only group results will be described. The group results of the study may be presented at a meeting or congress or issued in an accredited journal.

All the study material is coded and no associations can be made to your name. Your identity won't' be exposed during any time during or after the study. The data and information will be secured and not shared without your consent.

If you agree to participate in the study, please sign this sheet. If you do not agree to take part in the study, you are not required to sign the consent form.

Date of consent	**Signature of participant**

Informed consent:

I admit that I have read this consent form and are aware of the nature of this study as well as the possible benefits and risks involved. I realize that by agreeing to take part in this study I have not waived any legal or human right and that I may contact the researcher (Helena van de Wall) for any queries. I realize what my taking part in the study means and I willingly agree to partake in this study. I understand that I can refuse to take part or I can withdraw from the study at any time without consequence or penalty. I state that the information I have given is accurate at this period.

The protocol for this research will be submitted to the Health Sciences Research Ethics Committee of the University of the Free State for approval. The secretary of the Health Sciences Research Ethics Committee of the University of the Free State, may be contacted at 051-4052812 if any queries arise as to your rights as a partaker in the research.

Participant	Date
Participant Signature	Cell number
Research signature	Date

I have explained the study orally to the participant and I have required his/her understanding.

Appendix IV

FOR OFFICE USE ONLY

EVALUATION FORM POST-OPERATIVELY DATE:

1. Weight: ☐☐☐kg ☐☐☐ 1-3

2. Length: ☐,☐☐cm ☐☐☐ 4-6

3. Knee flexion in prone: ☐☐☐ 7-9

1. ☐☐☐°

2. ☐☐☐°

3. ☐☐☐°

Average: ☐☐☐°

4. Knee extension in prone: ☐☐☐ 10-12

1. ☐☐☐°

2. ☐☐☐°

3. ☐☐☐°

Average: ☐☐☐°

5. Difficulty in climbing stairs: ☐ 13

1. Yes ☐

2. No ☐

If yes, 1 ☐ ascending 14

2 ☐ descending

6. Swelling of painful knee: 15

1. Yes ☐

2. No ☐

If yes,

Measure superior ridge of patella Left (cm)

Right (cm)

7. Knee alignment/position 16

1. ☐ Genu Valgus

2. ☐ Genu Valgum

3. ☐ Normal

8. Onset of pain: ☐☐ Months 17-18

☐☐ Years 19-20

9. Comparable sign (most painful movement): 21

1. Flexion ☐

2. Extension ☐

3. Weight-bearing ☐

10. Did you receive physiotherapy before your operation? 22

1. No ☐

2. Yes ☐

If yes: how many sessions a week? 23

1. Once ☐

2. Twice ☐

3. Three times or more ☐

11. If you answered yes in question 11, how long did you receive treatment?

24

1. Less than four weeks ☐

2. One to three months ☐

3. More than three months ☐

12. Did you receive any other medical treatment before your operation?

1. No ☐ 25

2. Yes ☐

3. If yes, please specify 26

1. Psychiatric ☐

2. Biokinetics ☐

3. Other 

If other, specify please: _____

Appendix V FOR OFFICE USE ONLY

EVALUATION FORM PRE-OPERATIVELY DATE:

1. Weight: ☐☐☐kg ☐☐☐ 1-3

2. Length: ☐,☐☐cm ☐☐☐ 4-6

3. Knee flexion in prone:

1. ☐☐☐° ☐☐☐ 7-9

2. ☐☐☐°

3. ☐☐☐°

Average: ☐☐☐°

4. Knee extension in long sitting:

1. ☐☐☐°

2. ☐☐☐°

3. ☐☐☐°

Average: ☐☐☐°

☐☐☐ 10-12

5. Difficulty in climbing stairs: ☐ 13

1. Yes ☐

2. No ☐

If yes, 1 ☐ ascending ☐ 14

2 ☐ descending

6. Swelling of the knee? 15

1. Yes ☐

2. No ☐

If yes: Left knee _____cm - 10cm above patella and

Right knee _____cm

7. Knee alignment/position: 16

1. ☐ Genu Valgus

2. ☐ Genu Valgum

3. ☐ Normal

8. Comparable sign: 17

1. Flexion ☐

2. Extension ☐

3. Weight-bearing ☐

9. Did you receive physiotherapy in hospital with your operation? 18

1. No ☐

2. Yes ☐

If yes: how many sessions? 19

1. Once a day ☐

2. Twice a day ☐

3. How many days did you receive therapy in hospital?
20

1. 1-3 days ☐

2. 4-6 days ☐

3. More than 6 days ☐

10. Did you receive physiotherapy between hospitalisation and your six-week follow-up?

21

1. Yes ☐

2. No ☐

If yes, how many sessions?
22

1. One to three sessions ☐

2. Four to six Sessions ☐

3. Seven or more sessions ☐

11. Did you receive any other medical treatment after your operation?

1. No ☐
23

2. Yes ☐

3. If yes, specify please:
24

1. Psychiatric ☐

2. Biokinetics ☐

3. Other ☐

If other, specify please: _____

12. Did you receive a booklet with information about your operation?

1. Yes ☐
25

2. No ☐

Appendix VI

1903

Date: (month) / (day) / (year)

Subject's Initials : _____

Study Subject #:

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

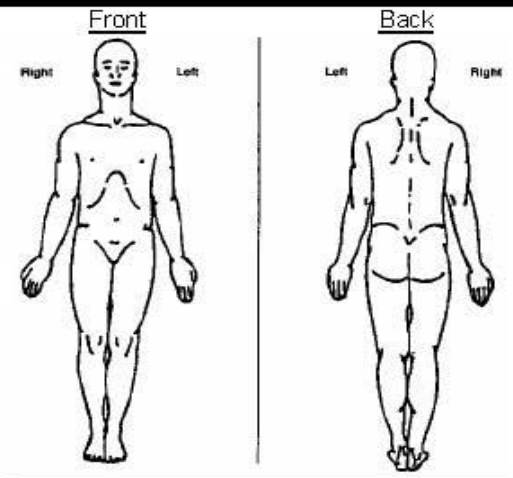
PLEASE USE BLACK INK PEN

Brief Pain Inventory (Short Form)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.



3. Please rate your pain by marking the box beside the number that best describes your pain at its worst in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

4. Please rate your pain by marking the box beside the number that best describes your pain at its least in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

5. Please rate your pain by marking the box beside the number that best describes your pain on the average.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

6. Please rate your pain by marking the box beside the number that tells how much pain you have right now.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

Page 1 of 2

1903

Date: ☐☐ / ☐☐ / ☐☐
(month) (day) (year)

Subject's Initials : _____

Study Subject #: ☐☐☐☐

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

PLEASE USE BLACK INK PEN

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please mark the box below the percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
☐ No Relief	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Complete Relief

9. Mark the box beside the number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

B. Mood

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

C. Walking ability

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

D. Normal Work (includes both work outside the home and housework)

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

E. Relations with other people

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

F. Sleep

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

G. Enjoyment of life

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

AppendixVII

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 VIII

DEMOGRAPHIC INFORMATION Office use only

TOTAL KNEE ARTHOPLASTY STUDY

Please complete the following questionnaire:

Tick with an X in the applicable box or write an answer in the space provided.

Participant's number: _____ ☐☐☐

1. **What is your age?** ☐☐ Years 1-2

2. What is your gender?

1. Male ☐
2. Female ☐ 3

3. What is your home language?

1. Afrikaans ☐ 4
2. English ☐
3. Sesotho ☐
4. Other ☐

4. What is your marital status?

1. Married ☐ 5
2. Single ☐
3. Divorced ☐

4. Living together ☐

5. Widow/Widower ☐

6. Other ☐

5. What is your household living status?

1. Alone ☐ 6

2. Family ☐

3. Other ☐

4. Old Age Home ☐

6. What were your initial diagnoses?

1. Rheumatoid arthritis ☐ 7

2. Osteo-arthritis ☐

3. Other ☐

If other, specify please: _____

7. What is your employment status/type?

1. Hard Labour ☐ 8

2. Office worker ☐

3. Other ☐

4. Retired/pension ☐

If other, specify please: _____

8. How long was the duration of your knee symptoms?

Years ☐☐ 9-10

9. Did you use a walking aid before surgery?

1. Yes ☐ 11

2. No ☐

10. Which chronic illnesses do you have? Tick all that apply please.

1. Diabetes ☐ 12

2. Hypertension (High blood Pressure) ☐

3. Cancer ☐

4. Asthma ☐

5. Other ☐

If other, specify please: _____

11. What is your highest educational level?

1. High School ☐ 13

2. Primary School ☐

3. College or University ☐

4. No schooling ☐

12. Which is your replacement side? Tick all that apply?

1. Left ☐
14

2. Right ☐

13. What is the number of this knee replacement you have had?

1. First replacement ☐
15

2. Second replacement ☐

3. Reoccurring ☐

14. Do you have any other joint OA?

1. No ☐
16

2. Yes ☐

3. If yes, where? : _____

15. Do you smoke?

1. No ☐
17 2. Yes ☐

3. Sometimes ☐

Appendix IX 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**
	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**
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**
	3	Very definitely and quite badly	3		Definitely
	2	Yes, but not too badly	2		I don't take as
	1	A little, but it doesn't worry me	1		I may not take quite
	0	Not at all	0		I take just as much
		I can laugh and see the funny side of things:			**I feel restless as I have to**
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**
	3	A great deal of the time	0		As much as I ever
	2	A lot of the time	1		Rather less than I
	1	From time to time, but not too often	2		Definitely less than
	0	Only occasionally	3		Hardly at all
		I feel cheerful:			**I get sudden**
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**
	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)

Appendix X

Standard Form – 36 (SF-36)
Standard Form 36 Survey: The SF-36 Form is one of many outcomes assessments designed by the Medical Outcomes Trust in Boston, MA. It is designed to approximate the improvement in health status from a medical intervention. **INSTRUCTIONS:** This survey asks for views about your health. This information will help keep track of how you feel and how well you are able to do your usual daily activities. Answer every question marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. During the past four weeks, have you had any of the following problems with your work or other regular daily activities as result of any emotional problems (such as feeling depressed or anxious)? (Circle the appropriate number for each question)		
a. Cut down on the amount of time you spent on work or other activities	Yes = 1	No = 2
b. Accomplished less than you would like	Yes = 1	No = 2
c. Didn't do work or other activities as carefully as usual	Yes = 1	No = 2

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours or groups? (Circle one)	1. Not at all 2. Slightly 3. Moderately 4. Quite a bit 5. Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks: (Circle one number on each line)

	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a. Did you feel full of pep?	1	2	3	4	5	6
b. Have you been a very nervous person?	1	2	3	4	5	6

c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt downhearted and blue?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives etc.)?(Circle one)	1. All of the time 2. Most of the time 3. Some of the time 4. A little of the time 5. None of the time

Appendix XI

Johan van der Merwe <orthodocjohan@gmail.com>
To: helena van der merwe

Thu, Aug 30, 2018 at 10:02 AM

Dis reg so met my

Show original message

Riaan Steyn <orthoriaan@mweb.co.za>
To: helena van der merwe

Wed, Sep 5, 2018 at 8:53 AM

Hi Helena
Jy is welkom om voort te gaan met jou studie en my pasient hierbij in te sluit
Groete
Riaan Steyn

Show original message

Re: Helena van de Wall Meestersgraad studie Fisioterapie

Yahoo/Inbox

Allan van Zyl <allan@orthodoc.co.za>
To: helena van der merwe

Sun, Aug 26, 2018 at 9:06 AM

Beste Helena,

Sal reg wees met my, sal net die logostieke wil bespreek tov Diny ens.

Maak 'n afspraak tyd by spreekkamer op tyd wat jou pas asb.

Beste groete,

Allan

Dr Allan A van Zyl
3a Third Ave, Westdene, Bloemfontein
Tel: 051-4483051
Cel: 0832524315
Email: allan@orthodoc.co.za

werner van der merwe
orthopaedic surgeon

05 November 2021

WIE DIT MAG AANGAAN

I/S: HELENA VAN DE WALL **ID: 780511 0131 088**

Hiermee gee ek Dokter Werner van der Merwe toestemming aan:

Helena van de Wall om my pasiënte te kontak vir haar studies.

Ons vertrou u vind bogemelde in orde.

Vriendelike groete,

WERNER VAN DER MERWE
2021.11.05

Appendix XII

MEDICLINIC

MEDICLINIC CORPORATE OFFICE
25 DU TOIT STREET
STELLENBOSCH
7600
SOUTH AFRICA

PO BOX 456
STELLENBOSCH
7599
SOUTH AFRICA

T +27 21 809 6500

www.mediclinic.co.za

02 November 2018

Miss Helena Van de Wall
12 James Scott Street
Westdene
Bloemfontein
9301

Dear Ms Van de Wall

PERMISSION TO CONDUCT RESEARCH AT MEDICLINIC BLOEMFONTEIN

Your research proposal entitled "Pain, function and health-related quality of life in total knee arthroplasty" refers.

It is in order for you to conduct your research at Mediclinic Bloemfontein and I wish you success with this project.

Yours sincerely

Dr Chris du Plessis
General Manager Clinical Services
MEDICLINIC SOUTHERN AFRICA

Appendix XIII

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

Health Sciences Research Ethics Committee

19-Sep-2018

Dear Miss Helena Van De Wall

Ethics Clearance: **PAIN, FUNCTION AND HEALTH-RELATED QUALITY OF LIFE IN TOTAL KNEE ARTHROPLASTY**

Principal Investigator: **Miss Helena Van De Wall**

Department: **Physiotherapy Department (Bloemfontein Campus)**

APPLICATION APPROVED

Please ensure that you read the whole document

With reference to your application for ethical clearance with the Faculty of Health Sciences, I am pleased to inform you on behalf of the Health Sciences Research Ethics Committee that you have been granted ethical clearance for your project.

Your ethical clearance number, to be used in all correspondence is **UFS-HSD2017/1527/2509**

The ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the HSREC for approval to ensure we are kept up to date with your progress and any ethical implications that may arise. This includes any serious adverse events and/or termination of the study.

A progress report should be submitted within one year of approval, and annually for long term studies. A final report should be submitted at the completion of the study.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite); Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely

Dr. SM Le Grange
Chair : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za
IRB 0000624; REC 230408-011; IORG0005187; FWA00012784
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa

Appendix XIV

To whom it may concern

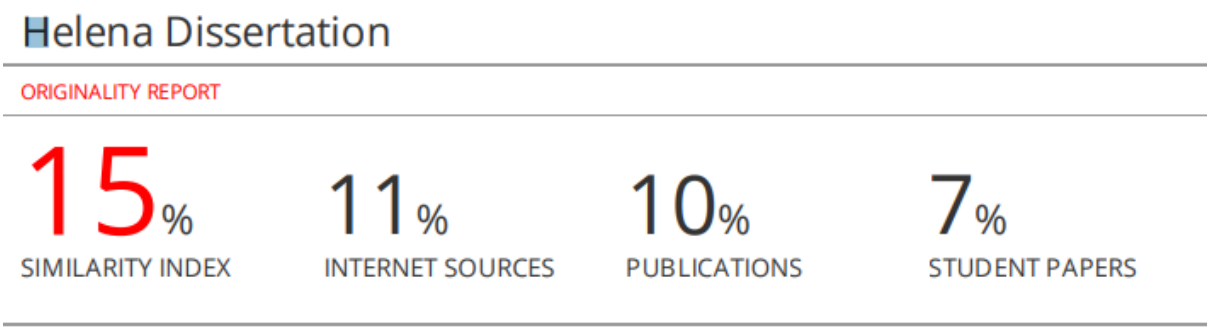
Turn-it-in report

Helena van de Wall

This letter confirms that I did submit my Dissertation, PAIN, FUNCTION AND HEALTH-RELATED QUALITY OF LIFE IN TOTAL KNEE ARTHROPLASTY, for the Turn-it-in report.

Although the report showed a 15% similarity index, certain standard terms are still identified although the settings have been set. This could be the cause that the percentage is still high.

I hope you find it in order.



Hereby I confirm that the 15% similarity includes standardised terms for example health related quality of life, picked up the standardised questionnaire utilised in the results section and picked up et al in most instances, which contributed to the similarity index.

Appendix XV


I.D.No. 780511 0131 08 8
S.A.BURGER/S.A.CITIZEN
VAN/SURNAME
VAN DE WALL
VOORNAME/FORENAMES
HELENA GERTRUIDA
GEBOORTEDISTRIK OF-LAND/
DISTRICT OR COUNTRY OF BIRTH
SUID-AFRIKA
GEBOORTEDATUM/
DATE OF BIRTH
1978-05-11
DATUM UITGEREIK
DATE ISSUED
2007-02-13
UITGEREIK OP GESAG VAN DIE
DIREKTEUR-GENERAAL:
BINNELANDSE SAKE
ISSUED BY AUTHORITY OF THE
DIRECTOR-GENERAL:
HOME AFFAIRS