Functional Outcomes Following Total Knee Arthroplasty Utilizing Lifestyle Risk Factors and Comorbidities on Performance-Based Tests

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Abstract

Total knee arthroplasty (TKA) is an orthopedic surgical procedure designed to alleviate the effects of knee osteoarthritis (OA), aiming to enhance patients' strength, range of motion (ROM), and ability to perform activities of daily living (ADL) post-operatively. Lifestyle risk factors and comorbid conditions are factors thought to impair recovery following TKA. Therefore, this research aimed to investigate the effect of lifestyle risk factors and the presence of comorbidities on both pre-operative and post-operative TKA patients, specifically evaluating their ability to perform functional tests.

Participants completed the Stair Climb Test (SCT), Stair Climb Power Test (SCPT), and Six-Minute Walk Test (SMWT). The study analyzed lifestyle risk factors and comorbidities alongside functional test scores collected before and six-months after TKA surgery. A two-way mixed factorial ANOVA was employed to assess the impact of smoking status, alcohol consumption, and the presence of comorbidities on functional performance measures, while a bivariate correlational analysis examined the relationship between BMI and performance outcomes.

28 participants completed the study. Non-smokers recorded the fastest time in seconds (s) on the SCT, SCPT, lowest average power in watts (W) on the SCPT and furthest distance walked in meters (m) on the SMWT compared to smokers/former smokers, both pre- and post-operatively. Smokers/former smokers averaged an improvement of 31.2% across all testing postoperatively with non-smokers improving averaging an improvement of 22.6%. For alcohol consumption status, non-drinkers recorded the fastest time for the SCT (s), SCPT (s; pre- and post-operatively), and highest average power on the SCPT (W; pre- and post-operatively) compared to drinkers. Non-drinkers recorded the furthest distance walked on the SMWT (m;

post-operatively) compared to drinkers with an improvement on the SCT (s) of 35.9% and 29.8% on the SMWT (m) post-operatively. Non-drinkers improved by 31% and 18.5%, respectively on the same testing measures. Drinkers had an average improvement of 25.4% across testing measures post-operatively with no-drinkers having an average improvement of 27.3%. Participants with ≤ 1 comorbidity recorded the fastest time on the SCT (s; pre- and post-operatively) and SCPT (s; pre-operatively) compared to participants with ≥ 2 comorbidities. Participants with ≤ 1 comorbidity recorded the slowest time on the SCPT (s; post-operatively), highest average power on the SCPT (W; pre- and post-operatively), and furthest distance walked on the SMWT (m; pre- and post-operatively). Participants with ≥ 2 comorbidities had an average improvement of 33.9% across all testing measures post-operatively while participants with ≤ 1 comorbidity had an average improvement of 20.9% post-operatively.

The outcomes of this study may suggest that individuals who present with lifestyles risk factors and/or comorbidities may be linked to poor functional performance. However, due to limited participants resulting in decreased generalizability, this study lacks conclusive evidence. Future research may need to combine these functional testing measures with other objective measures such as pain, ROM, and/or strength along with other noted complications rather than functional tests being used in isolation.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ACL – Anterior cruciate ligament

ADL – Activities of daily living

AL – Anterolateral

AM – Anteromedial

BMI – Body mass index

KOOS – Knee Injury and Osteoarthritis Outcome Score

LCL – Lateral collateral ligament

LEFS – Lower Extremity Functional Scale

MCL – Medial collateral ligament

MDC – Minimum detectable change

OA – Osteoarthritis

PCL – Posterior cruciate ligament

PL – Posterolateral

PM – Posteromedial

ROM – Range of motion

SCPT – Stair Climb Power Test

SCT – Stair Climb Test

SEM – Standard error of measurement

SMWT – Six-Minute Walk Test

TKA – Total knee arthroplasty

USA – United States of America

Predictors of Functional Outcomes Following Total Knee Arthroplasty Utilizing Performance-Based Tests

As the medical industry continues its race to keep up with the exponentially growing population; advancing and innovative science has focused on illness and disease, resulting in the world population reaching a higher life expectancy than ever before (Johnson & Hunter, 2014). Advancements in medicine, drug therapies, and surgical procedures have not only increased life expectancy but also the quality of life (Kennedy et al., 2008; Londhe et al., 2021). This outcome is the primary focus in the discipline of orthopedics. Knowledge, innovation, and precision have pioneered new and improved approaches to replace damaged and diseased bodily tissue with artificial materials to act in unison with the human body (Bellemans et al., 2005; Oatis et al., 2019). TKA is a commonly performed surgical procedures conducted worldwide with the desired post-operative outcome being the restoration of function and decreased pain (Groen et al., 2012; Seil & Pape, 2011).

Knee OA is a degenerative joint disease that occurs when the cartilage lining the knee joint gradually breaks down, causing pain, stiffness, swelling, and decreased mobility (Bedard et al., 2018). This condition typically develops over time as the wear and tear of the cartilage leads to friction between the bones, which can result in inflammation and further damage to the joint (Abdelmegied et al., 2020). OA is more common in older adults but can also be influenced by factors such as obesity, joint injuries, or genetics with symptoms ranging from mild discomfort to severe pain, making it difficult to perform everyday activities like walking or climbing stairs (Archunan et al., 2021). Over time, knee OA can significantly impact quality of life and may require treatments ranging from physical therapy and medications to surgical interventions, including knee replacement in advanced cases (Masaracchio et al., 2017).

The prevalence of total knee arthroplasty (TKA) is projected to increase by over 600% by 2030 (Bedard et al., 2018; Franklin et al., 2008). Progressive knee osteoarthritis (OA) has a higher risk of leading to disability than any other medical condition common to elderly people (Masaracchio et al., 2017. The leading cause of joint arthroplasty is OA which is a degenerative disease and the primary cause of joint degeneration (Capin et al., 2022; Kane et al., 2005). The progression of OA can be accelerated by a variety of factors that include age, injury, illness, and genetic differences that predispose people to osteoarthritic changes (Yue et al., 2022). As the human body progresses through life, exposure to injuries and illness is common resulting in progressive damage and/or potential failure of the knee joint (Masaracchio et al., 2017; Seil & Pape, 2011; Singh, 2011). Orthopedic surgeons will suggest a TKA to alleviate the pain and debilitating symptoms of knee OA (Abdelmegied et al., 2020) after all conservative management options have been exhausted.

TKA is one of the most prevalent cutting-edge orthopedic surgeries performed worldwide to remove diseased and/or damaged bone in conjunction with cartilaginous materials that are affected by progressive knee OA and replaced with artificial components to repair the knee joint (Brock et al., 2017; Michael et al., 2010; Yue et al., 2022). Research has reported that the population over 65 will total over 69 million in the United States of America (USA) thus resulting in an inevitable increase in TKA procedures (Archunan et al., 2021; Bedard et al., 2018; Masaracchio et al., 2017). Additionally, research conducted by Fransen et al. (2017) highlighted that based on a review of 18 countries, the epidemic concerning healthcare resources towards TKA surgeries is projected to increase at an annual compounding rate of 5-17%. Currently, over 3.5 million TKA procedures were performed in the USA each year over the last decade with hospital expenditures surpassing billions each year, for reference, 28 billion dollars was spent solely on TKA procedures in 2009 alone (Masaracchio et al., 2017). As the continuously aging population increases, so will the incidence of TKA procedures (Archunan et al., 2021). The incidence of TKA procedures is expected to increase by over 600% from 2009 to 2030, placing an additional burden on healthcare systems (Bedard et al., 2018; Franklin et al., 2008; Masaracchio et al., 2017).

With the increase in TKA procedures, there has been a linear increase in poor surgical outcomes resulting in minimal improvement (Archunan et al., 2021; Gold et al., 2020). Additionally, 25% of patients failed to achieve clinically significant functional outcomes following TKA surgery, which resulted in an increased risk of revision surgeries (Bonnefoy-Mazure et al., 2017; Fransen et al., 2017; Wellman et al., 2017). Previous literature has highlighted that there is a growing concern surrounding the success of TKA surgeries, due to patients' reported pain and decreased function at six-month, and one-year post-operative follow-up appointments (Franklin et al., 2008; Fransen et al., 2017). Primarily, a reduction in pain, restoration of function, and return to ADL is commonly not obtained across the population receiving TKA surgeries (French et al., 2010; Kennedy et al., 2008; Ozden & Tumturk, 2022).

Overall, the variety of comorbid factors, lifestyle risk factors, and increasing population are resulting in higher incidences of TKA failure and poor outcomes such as a minimal decrease in pain and poor restoration of functional movement (Bellemans et al., 2005; Gromov et al., 2019; Lungu et al., 2014). Limited conclusive evidence currently exists surrounding factors that may allow for the prediction of positive and/or negative outcomes following TKA surgeries. Factors that affect TKA outcomes pre- and post-operatively are well documented, however, there is a gap in the existing body of research pertaining to predictive factors of functional outcomes following TKA surgery. Thus, research is warranted exploring factors that may lead to more or less successful outcomes following TKA surgery. Therefore, it may be beneficial to the existing body of research to understand the factors that determine the success of a TKA surgery and delineate if there are predictive measures that can be implemented to understand what leads to a more or less successful outcome.

Chapter 1: Literature Review

Osteoarthritis

Pathophysiology

OA is a result of mechanical, cellular, and biomechanical factors, coupled with various risk factors, leading to joint degeneration (Johnson & Hunter, 2014). The Kellgren and Lawrence grading system is employed to define OA pathologically, radiographically, or clinically, with a score greater than 2 indicating radiographic OA in the knee joint (Johnson & Hunter, 2014). Early osteoarthritic cartilage is observed as thicker and swollen due to disruption of the collagen network. As knee OA progresses, up-regulation of cell proliferation occurs, resulting in chondrocyte clusters. This process, however, becomes unsustainable, leading to the loss of integral properties in the cartilage and extracellular matrix due to an inability to respond to growth factors (Johnson & Hunter, 2014)As knee OA progresses, the subchondral bone undergoes specific adaptations in response to the progressive development of OA, particularly knee OA, leading to increased subchondral plate thickness, sclerosis, and joint space narrowing (Bellemans et al., 2005; Singh, 2011). This cascade of events results in reduced matrix mineralization, increased cancellous bone volume, formation of osteophytes, and the development of bone cysts (Johnson & Hunter, 2014). These factors force alterations in the joint surfaces, causing abnormal joint congruity and contributing to the progression of knee OA (Seil et al., 2011). Singh et al. (2017) reported additional damage to the articular cartilage, stating that the progression toward synovial inflammation leads to the release of proteinases, inflammatory cytokines, matrix metalloproteinases, and aggrecanase, worsening cartilage damage. These inflammatory responses, including osteophyte development, were reported to irritate sensory nerve endings within the synovium, causing pain (Johnson & Hunter, 2014; Seil et al., 2011; Singh et al., 2017). Monitoring the progressive effects of knee OA through magnetic resonance imaging and radiographs revealed structural changes which included joint space narrowing and bone density loss (Johnson & Hunter, 2014). Damaged menisci are primary indicators of patients with progressive knee OA, leading to meniscal lesions (Kopf et al., 2009; Logterman et al., 2018; Marchant et al., 2011; Meister et al., 2000).

Furthermore, Johnson and Hunter (2014) explained that 82% of patients displaying severe knee OA on radiographic imaging had meniscal damage with accompanying lesions. Severe knee OA occurs when most or all of the cartilage within the joint has worn away, thus the lack of cartilage results in more damage to the surrounding bone and impairs the integrity of the knee joint (Allen et al., 2022). Allen et al. (2022) reported that OA has detrimental effects on the anatomical structures of the knee joint, leading to cartilage degradation, bone remodeling, and osteophyte formation. A cohort study by the same authors indicated that over 235 million individuals aged 60 years old and above suffer from symptomatic OA. Furthermore, recent studies on knee OA in the USA reveal symptomatic cases in over 14 million people. The progression of OA was reported to be influenced by age, injuries, and underlying medical conditions, with additional risk factors, particularly for knee OA, including prior traumatic injury, obesity, and joint injury (Allen et al., 2022). High blood pressure, genetic factors, metformin use, bone mineral density, abnormal joint shape and malalignment, and lower muscle strength/quality are also reported as accelerators of OA and knee OA (Allen et al., 2022).

Epidemiology

Progressive OA poses a higher risk of disability than many other medical conditions common among the elderly (Franklin et al., 2008; Johnson et al., 2014). OA, as described by Michael et al. (2010), reflects the extent of damage to the cartilaginous materials of the knee joint and surrounding structures during the aging process. Franklin et al. (2008) noted that knee OA affects approximately 40% of men and 47% of women. TKA has been proposed to provide pain relief for knee OA and significantly enhanced function at six and twelve-month follow-ups post-surgery (Franklin et al., 2008).

Knee OA stands out as the primary contributor to decreased knee joint function globally, and its association with pain and anatomical degeneration often leads to the necessity of TKA to alleviate progressive symptoms (Holm et al., 2020; Signgh, 2011). These symptoms progressively impede ADL, such as walking, ascending and descending stairs, and rising from seated positions (Holm et al., 2020). Johnson and Hunter's (2014) research highlighted OA as a leading cause of disability, with an anticipated exponential increase in incidence. Overall, 300 million people have symptomatic knee and hip OA worldwide with knee OA having a higher prevalence of knee OA (Young et al., 2023). Approximately 4 million Canadians live with symptomatic knee and hip OA as reported by Young and colleagues (2023). Symptomatic knee OA is defined as OA that presents with knee pain/joint stiffness in the absence of any recent trauma or injury (Young et al., 2023). Similar research conducted by Cui and colleagues (2020) also reported a similar number with the prevalence of patients presenting with symptomatic knee OA based on radiographic knee OA findings, of the total population being 10-14% in the USA, 15-19% in Canada, and 20-24% in Mexico, Sweden, China, and India. A higher prevalence of symptomatic knee OA across the total population was reported in other countries which included but was not limited to Korea (35-29%), Japan (40-44%), and Thailand (45-49%) which has become a growing concern worldwide (Cui et al., 2020).

Factors such as rising obesity levels, a higher prevalence of lifestyle risk factors, and an aging population contribute to the increased incidence of symptomatic knee OA (Holm et al., 2020). Moreover, age, sex, genetics, and knee joint-specific factors like misalignment and abnormal loading were reported to exacerbate the global burden of OA and, more specifically, knee OA (Johnson & Hunter, 2014). In comparing these perspectives, the studies collectively emphasized the profound impact of progressive OA on disability, shedding light on the prevalence of knee OA and the pivotal role of TKA in alleviating symptoms. They also underscore the multifactorial nature of OA, incorporating elements of age, genetics, lifestyle, and knee joint-specific factors (Pourmoghaddam et al., 2016; Singh, 2011). This holistic understanding is crucial for addressing the challenges posed by OA and informing effective interventions to improve the quality of life for those affected. The incidence of knee OA varies across countries, with reported rates for individuals over 50 years of age being 35.1% in Korea, 17.4% in the United Kingdom, and 13.8% in Spain (Allen et al., 2022). OA, as a progressive disease, affects joint structures, tissues, ligament integrity, and the surrounding musculature (Archunan et al., 2021; Singh, 2011).

Primary risk factors are factors that lead/may lead to an adjacent health problem, the degree to which the factor(s) lead to the causation and/or progressive worsening of a health problem varies widely and are determinants of the number of risk factors present (Best et al., 2015; Gold et al., 2020) Factors influencing OA and knee OA progression were reported to include obesity and abnormal radiographic features and biomechanical stress (Allen et al., 2022; Best et al., 2015; Gold et al., 2020). Considering the significant effects of OA on quality of life it is essential to have successful treatments to treat the symptoms and increase quality of life in patients with OA.

Two main treatments for knee OA are non-pharmacological therapies, such as physical therapy, weight loss in obese patients, or device-based treatments, and pharmacologic therapies primarily aimed at alleviating pain and improving/preserving functional ability (Lungu et al., 2014; Mizner et al., 2011). Individuals with knee OA generally lead more sedentary lives and often experience limitations in daily activities, reporting lower overall daily activity than the average individual (Lin et al., 2021). Masaracchio et al. (2017) reported the World Health Organization's expectation of a continued increase in OA cases. The average reported cost of OA range between $2000-5000 United States dollars (USD) annually for each individual, impacting over 27 million people in the United States of America (USA; Archunan et al., 2021; Masaracchio et al., 2017).

The prevalence knee OA has led to a surge in inpatient surgeries for TKA in the USA, with projections indicating an increase (Franklin et al., 2008; Fransen et al., 2017). As for the challenges associated with knee OA, difficulties progressively intensify, impacting ADL such as walking, ascending and descending stairs, and rising from seated positions (Holm et al., 2020). The increasing prevalence of knee OA, coupled with its substantial impact on daily life and the economic burden it poses, emphasizes the critical need for effective prevention and management strategies.

Etiology

Knee OA can manifest as primary or secondary. Primary knee OA is primarily attributed to the natural degeneration of articular cartilage surrounding the knee joint due to the passage of time and aging (Michael et al., 2010). While primary knee OA is considered inevitable, its functional impact varies among individuals and is not solely caused by a single distinguishable factor (Michael et al., 2010). Johnson and Hunter (2014) explained that the primary causes of knee OA involve factors leading to cartilaginous changes, such as damage to the menisci or adjacent ligaments, ultimately resulting in cartilage destruction. Joint damage, particularly meniscal lesions, catalyzes the development of knee OA (Johnson & Hunter, 2014). Weight management was identified as a primary cause of knee OA, with evidence suggesting that for each kilogram of weight loss, the knee experiences a fourfold reduction in load during ADL (Johnson & Hunter, 2014).

On the other hand, secondary knee OA is caused by localized forces on the knee joint from previous injuries. Other forms of arthritis such as rheumatoid arthritis, infections, and poor health, are also all contributing factors in the progressive development of knee OA (Michael et al., 2010). The majority of individuals with knee OA are reported to be overweight or obese, often associated with additional risk factors like smoking and diabetes (Bonnefoy-Mazure et al., 2017; Groen et al., 2012). Unfortunately, factors such as smoking, alcohol consumption, and diabetes are also leading contributors to obesity. In this context, weight management is sometimes overlooked as a strategy to reduce the need for TKA, with more attention focused on these more prominent risk factors (Johnson & Hunter, 2014). Recognizing both primary and secondary factors contributing to knee OA is essential for implementing effective preventative measures and optimizing treatment strategies.

Physical Function

Ligaments

The knee joint consists of the tibiofemoral and patellofemoral joints (Kopf et al., 2019), and is a lever-class joint facilitating articulation between the femur tibia and patella. Four major ligaments are crucial for the support and stabilization of the knee joint, these include the anterior cruciate ligament (ACL), posterior cruciate ligaments (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL; Kopf et al., 2009; Logterman et al., 2018; Marchant et al., 2011; Meister et al., 2000).

Anterior and Posterior Cruciate Ligaments.

The ACL is a key ligament that helps with knee stabilization by connecting the femur to the tibia (Kopf et al., 2019). The ACL originates on the medial wall of the lateral femoral condyle and inserts into the middle intercondylar area (Kopf et al., 2019). This ligament plays a pivotal role in limiting anterior translation of the tibia and restricting rotational knee movements (Kopf et al., 2009). The ACL is composed of two bundles, the anteromedial (AM) and posterolateral (PL), that are arranged horizontally at 90 degrees of knee flexion, with the PL bundle positioned anterior to the AM bundle (Kopf et al., 2009). During knee extension, the bundles are also arranged horizontally, but the AM bundle is proximal to the PL bundle. Notably, the AM bundle experiences higher tension between 30-90 degrees, while the PL bundle has increased tension from 0-30 degrees of knee flexion (Kopf et al., 2009). Controversy exists regarding which bundle provides superior rotational stability, with some reports suggesting the AM bundle is more stabilizing (Kopf et al., 2009). The degree of tension and direction of tension placed on the ACL can vary throughout movements while also having higher degrees of strain placed on it throughout knee OA progression (Kopf et al., 2009). This strain can also begin to impair the integrity of the ligaments adjacent to counter-partner the PCL.

The PCL is another key ligament of the knee joint that also assists with stabilization, this ligament is also stronger than all other knee joint ligaments (Marchant et al., 2011). The PCL originates on the anterolateral (AL) aspect of the medial femoral condyle and inserts along the posterior aspect of the tibial plateau (Logterman et al., 2018). The PCL reportedly limits the posterior translation of the tibia in relation to the femur while also assisting in preventing rotational movements (Logterman et al., 2018). In contrast, the PCL is twice the thickness of the ACL and is also comprised of two bundles including an AL and posteromedial (PM) bundles (Marchant et al., 2011). The PCL acts as a secondary stabilizer, limiting excessive knee rotation between 90-120 degrees of knee flexion, with the AL bundles primarily tensioned in knee flexion and the PM bundles in knee extension (Marchant et al., 2011). Similar to the ACL, the degree of tension and direction of tension placed on the ligament is ever-changing throughout movements (Kopf et al., 2009).

Although the ACL and PCL are not directly affected by knee OA, the detrimental effects that OA has on the surrounding knee joint were reported to impair the function of these ligaments (Logterman et al., 2018; Podmore et al., 2018). Maldistribution of weight across the tibial plateau may result in patient-specific compensation which places patients in unstable positions resulting in a higher possibility of ligament injury (Bellemans et al., 2005; Logterman et al., 2018). Similarly, the degeneration of surrounding cartilaginous materials and bone integrity has a detrimental effect on the MCL and LCL (Pourmoghaddam et al., 2016). Literature has shown that the degree to which weight distribution changes throughout knee OA progression does correlate with ACL and PCL impairment which was supported by Bellemans and colleagues (2005).

Medial Collateral and Lateral Collateral Ligaments.

The MCL is the ligament on the medial aspect of the knee joint which has the primary responsibility of keeping your tibia and femur in position during valgus stress and rotational forces (Marchant et al., 2011). The MCL originates on the medial aspect of the distal femur and inserts on the medial aspect of the proximal tibia (Marchant et al., 2011), and serves as a key player in preventing valgus stress on the knee joint. Valgus stress results from forces applied to the lateral aspect of the knee, directing the knee joint medially (Marchant et al., 2011; Pourmoghaddam et al., 2016). The MCL consists of three components including superficial, deep, and posterior oblique fibers. This complex prevents valgus stress while significantly contributing to preventing rotatory motion and anterior-posterior translation (Marchant et al., 2011; Kopf et al., 2009). Reinforced by the pes anserine during knee extension and supported by expansions of the semimembranosus tendon during flexion, the MCL complex experiences the highest force at 60 degrees of knee flexion and effectively resists valgus stress at 25 degrees (Marchant et al., 2011). The MCL begins to experience impairment in function as the maldistribution of forces through the tibial plateau affects the amount and direction of forces placed on the knee joint (Pourmoghaddam et al., 2016). Consequently, this can also affect the integrity of the ligament that acts in opposition to the MCL which is the LCL.

The LCL is similar to the MCL and acts as a lateral stabilizer of the knee joint by resisting varus stress (Meister et al., 2000). The LCL originates on the lateral epicondyle of the femur and inserts on the fibular head (Meister et al., 2000) and primarily functions to prevent varus stress on the knee. Varus stress results from forces applied to the medial aspect of the knee, forcing the knee joint laterally (Meister et al., 2000). On the other hand, the LCL, consisting of anterior and posterior fibers, remains taut throughout all degrees of flexion. Although it prevents varus stress at 25 degrees of knee flexion, it is generally considered weaker than the MCL (Meister et al., 2000). Although similar, there is a discrepancy comparing the MCL and LCL as the LCL is weaker and often impaired either first or before the MCL as knee OA destroys the joint integrity and alters weight distribution (Seil & Pape, 2011).

Similar to the ACL and PCL, the MCL and LCL are not primarily impacted by knee OA, however, the degree to which OA damages the knee joint may result in impairments of these ligaments (Marchant et al., 2011; Meister et al., 2000). As further destruction occurs on the articulating surfaces of the tibiofemoral joint caused by knee OA, joint kinematics are reported to be affected and may progressively worsen (Meister et al., 2000; Seil & Pape, 2011). Based on the individual and specific degree of knee OA present, the excess force can be placed on the medial and/or lateral aspect of the tibial plateau as reported by Marchant and colleagues (2011). This change in kinematics may result in additional stretching and/or varus/valgus deformities within the knee joint ultimately affecting the integrity of the MCL and LCL (Londhe et al., 2021; Marchant et al., 2011; Meister et al., 2000). While the purpose of the knee ligaments are to stabilize the joint, they are equally as important as the muscles surrounding the knee joint which have the primary purpose of creating movement and force production (Lungu et al., 2014).

Muscles

Various muscles play a role in creating movement and force production at the knee joint. These muscles can be categorized into lower extremity muscles. The muscles of the lower extremity that act on the knee joint can be further classified into anterior, posterior, and medial thigh muscles along with posterior shin muscles (Ronai & Gallo, 2020).

The anterior thigh muscles that act on the knee joint include the four quadricep muscles and the sartorius, while the posterior thigh muscles include the three hamstring muscles (Landin et al., 2016; Ronai & Gallo, 2020). Compared to the anterior and posterior thigh muscles, only one muscle from the medial thigh acts on the knee joint which is the gracilis (Landin et al., 2016). The posterior shin muscles that act on the knee joint include the gastrocnemius, popliteus, and plantaris (Ronai & Gallo, 2020).

The actions of these muscles play particular importance for individuals presenting with knee OA and those receiving a TKA due to potential limitations such as weakness and decreased force production through the knee joint. (Lungu et al., 2014; Ronai & Gallo, 2020). A high degree of muscle function is needed to adequately complete and/or return to normal ADL, thus the degree of muscle strength and ROM impairment, if present, acting on the knee joint directly relates to the degree of difficulty of ADL (Lungu et al., 2014).

Strength and Range of Motion.

The maintenance or improvement of strength is crucial in determining the effectiveness of a TKA procedure (Capin et al., 2022; Gromov et al., 2012). According to Capin et al. (2022), TKA resulted in a reduction in strength loss exceeding 50% for both the quadriceps and hamstring muscles. Additionally, a 20% strength reduction was reported for the ankle dorsiflexors and plantarflexors (Cain et al., 2022; Kane et al., 2005; Lungu et al., 2014). Similarly to muscle maintenance and strength, the degree of ROM and the presence of pain during movement serve as key indicators for assessing the success of TKA procedures post-operatively (Capin et al., 2022).

Maximal and/or improved ROM and the absence of pain or muscle weakness indicated a successful outcome following TKA (Capin et al., 2022). TKA patients often present with strength and ROM impairments pre- and post-operatively which is linked to a worse recovery and higher incidence of complication post-operatively (Ozden & Tumturk, 2022). Incorporation of walking tests such as gait analysis or the Six-Minute Walk Test (SMWT) are often used as limitation indicators of current physical ability and progression in both pre- and post-TKA surgery (Hatfield et al., 2011) Thus, an emphasis placed on muscle strength and ROM may be of importance when treating TKA patients both pre- and post-operatively. Additionally, it may be of great significance to assess patients' ability to ambulate pre- and post-operatively to help indicate strengths and/or limitations.

Gait Analysis.

Ambulation refers to one's ability to walk and is often used to assess the degree of impairment or recovery following conservative treatment of knee OA and after TKA procedures (Ozden & Tumturk, 2022). Unimpaired gait or normal gait involves a coordinated and efficient way an individual walks. The length and width of strides, the cadence or steps per minute, foot placement, upright posture, synchronized arm swing, balance, and stability are key aspects of a normal gait (Hatfield et al., 2011) These components contribute to a balanced and efficient walking pattern. Deviations from these norms may signal gait abnormalities or inefficiencies, which should be evaluated and addressed by healthcare professionals (Hatfield et al., 2011; Podmore et al., 2018). Research conducted by Hatfield et al. (2011) involving kinematic analysis revealed the presence of ROM limitations following TKA in their cohort of participants. The findings by Hatfield and colleagues (2011) displayed increased knee flexion angles during the standing phase and decreased knee extension angles during walking which was supported by

Ozden and Tumturk (2022). Increased knee flexion during the standing phase was associated with a higher incidence of implant failure and anterior knee pain. Moreover, walking with decreased knee flexion after heel strike significantly impaired the dispersion of forces placed on the knee joint (Hatfield et al., 2011; Podmore et al., 2018). Decreased ROM leads to increased forces being placed on specific areas throughout the tibial plateau during walking which leads to additional ROM limitations and stiffness (Archunan et al., 2021)

Stiffness or decreased ROM, defined by Archunan et al. (2021) is a flexion contraction reater than 15 degrees and/or flexion less than 75 degrees, which was observed in 2.44% of TKA patients. Measurement of the joint both pre- and post-operatively is often done to determine the amount of stiffness and/or ROM limitations that are present (Archunan et al., 2021). This assessment can be used as a predictive measure for contractures.

A contracture is the tightening of muscles, tendons, skin, and/or additional surrounding tissues of the affected joint resulting in the affected joint(s) becoming increasingly rigid (Archunan et al., 2021). A contracture can be the result of an injury and/or factors that result in increased inactivity leading to limited joint use and decreased ROM (Campbell et al., 2019). Patients who have knee OA are at a higher risk of contractures due to additional stiffness and/or fear of moving. Additionally, patients who have knee OA are frequently reported to have joint tightness and ROM restrictions (Archunan et al., 2021; Campbell et al., 2019). Previous reports highlight that 30-50% of patients with knee OA will develop contractures in the affected joint resulting in a compounding effect of OA-specific symptoms such as added pain and/or stiffness from the limited mobility (Campbell et al., 2019). Joint contractures in the lower limbs were reported to negatively affect ambulation, increase energy expenditure, risk of falls, and mechanical stress on the affected and adjacent joints (Campbell et al., 2019). Overall, individuals with knee OA should be urged to maintain the highest degree of ROM possible and be consistent with ambulation day-to-day (Archunan et al., 2021)

Research on knee OA patients who had joint manipulation under a general anesthetic post-TKA surgery showed that contractures decreased by 4.4 degrees, with the mean flexion of the knee showing an improvement of 41.4 degrees in TKA patients. Before manipulation, 2.44% of patients exhibited a mean contracture of over 4 degrees and a mean reduced flexion of the knee by 41.4 degrees. Notably, improvements occurred only with additional manipulation (Archunan et al., 2021). The degeneration of these structures because of OA is extremely common and has a negative effect on quality of life and daily function. Additionally, functional testing focused on quadricep muscle activation and ROM may be a better indicator of recovery following TKA and the degree to which knee OA has progressed.

Total Knee Arthroplasty

TKA is defined by Brock et al. (2017) as a surgical procedure aimed at eliminating the effects of knee OA and improving functional outcomes. TKA is reported as the most common and effective treatment for end-stage knee OA (Hatfield et al., 2011). Given its success, TKA has been increasingly utilized. According to Brock et al. (2017), TKA involves cutting and/or shaving away damaged bone and cartilage where the femur and tibia articulate. Anatomical properties and tissue affected by OA are excised and replaced with an artificial joint, which then serves as the new articulating surface in place of the damaged cartilaginous material (Brock et al., 2017; Michael et al., 2010; Yue et al., 2022). A TKA is performed to alleviate pain from knee OA and improve function by repairing damage caused by OA to hyaline cartilage and the extracellular matrix that lines the bone (Brock et al., 2017; Groen et al., 2012; Kane et al., 2005). Hyaline cartilage is composed of an extracellular matrix that allows cells to attach and communicate with other cells and is responsible for cell growth, movement, and regeneration (Michael et al., 2010). The extracellular matrix is gradually affected by mechanical forces from movement transferred through the knee joint (Michael et al., 2010). Knee OA impairs the kinematics of the knee joint resulting in the inefficient dispersion of forces causing damage to the joint and surrounding structures (Bennell et al., 2011). Components of OA include damage to the extracellular matrix, mechanical forces on the joint capsule leading to degeneration of the knee joint (Abdelmegied et al., 2020; Michael et al., 2010; Wellman et al., 2017).

The degeneration process occurs continuously throughout life and is accelerated by additional mechanical stress (Bennell et al., 2011; Podmore et al., 2018). Various structures including muscles and ligaments work simultaneously to support, stabilize, and produce movement through the knee joint but as knee OA progresses, an increased strain is placed on the functionality of the knee joint and its surrounding structures (Podmore et al., 2018).

Lifestyle Risk Factors.

Smoking.

Smoking emerged as a prevalent lifestyle risk factor within the TKA population, with Yue et al. (2022) emphasizing its high prevalence and anticipating its continued growth in relation to TKA procedures. National databases reveal that 10-40% of TKA patients are smokers, exposing them to increased risks of systemic and surgical complications, poor wound healing, and decreased blood flow, potentially hampering recovery after TKA (Bedard et al., 2018; Yue et al., 2022). Habitual smokers face significant challenges, given the strain on their cardiovascular system, making it more difficult to prescribe exercise at moderate intensity for rehabilitation and exercising at least 30 minutes, 5 days a week (Bedard et al., 2018).

Shockingly, research indicated that 50% of patients, on average, do not complete rehabilitation, and 42% do not adhere to any recommendations (Bedard et al., 2018).

In a sample population of smokers compared to non-smokers analyzed by Bedard et al. (2018), univariate analysis revealed that 11.6% were smokers, exhibiting higher rates of wound complications (3.8% versus 1.8%), deep infection (2.5% versus 1.0%), pneumonia (1.3% versus 0.4%), and reoperation after TKA (5.0% versus 3.1%) Smoking adversely affects health, increasing the likelihood of requiring revision surgery, experiencing wound complications, and facing a higher incidence of surgical complications (Bedard et al., 2018). Smoking has been shown to elevate the incidence of vasoconstriction, leading to decreased blood flow, increased hypoxia, and reductions in collagen production (Bedard et al., 2018; Bonnefoy-Mazure et al., 2017; Brock et al., 2017). Importantly, Bedard et al. (2018) underlined the significance of smoking cessation due to the associated negative health risks and surgical complications. Furthermore, smoking significantly increases the risk of various complications, including unplanned intubation, deep venous thrombosis, pulmonary embolism, renal insufficiency, and acute renal failure (Archunan et al., 2021).

Additionally, urinary tract infection, stroke, cardiac arrest, myocardial infarction, and the need for blood transfusions were also reported complications (Archunan et al., 2021; Bedard et al., 2018). The multifaceted impact of smoking on TKA outcomes underscores the importance of addressing this risk factor comprehensively in pre-operative planning and intervention strategies. Implementing effective smoking cessation programs and interventions during the pre-operative phase may significantly contribute to improved surgical outcomes, reduced complications, and enhanced overall recovery for TKA patients.

Alcohol Consumption.

Alcohol consumption poses another global public health concern for consideration, affecting over 10% of the world's population (Best et al., 2015; Deng et al., 2021). More than 76 million individuals grappling with alcohol use disorders and over 3 million alcohol-related deaths are reported annually worldwide (Gold et al., 2020; Rotevatn et al., 2017). In the USA, 10% of the population was reported to struggle with alcohol disorders, marking a 50% increase in this specific population over the last decade (Deng et al., 2021). Known for its impact on immune system function and the hindrance of wound healing, alcohol consumption was reported to be linked to post-operative infections and prosthetic complications/failures (Gold et al., 2020). Patients scheduled for TKA surgery undergo routine pre-operative screening and are informed about the negative health effects associated with alcohol use, emphasizing the risks of intra- and post-operative complications (Rotevatn et al., 2017).

Current medical literature detailed the effects of intra- and post-operative complications for patients with alcohol use disorders, indicating higher probabilities of joint failure, rehospitalization, and increased mortality rates (Best et al., 2015; Deng et al., 2021). However, Rotevatn et al. (2017) argued that limited research has been conducted on patients who consume alcohol at low-moderate rates. Rotevatn and colleagues (2017) suggested that pre-operative alcohol consumption is associated with an increased risk of post-operative morbidity in TKA patients, but contradictory statements report that low-moderate alcohol consumption is not linked to post-operative complications in TKA with limited research presented on the subject. Deng et al. (2021) also discussed the post-operative complications associated with high alcohol use and alcohol use disorders but provided no information regarding low-moderate alcohol consumption.

Alcohol can be directly related to other comorbidities with negative health effects, such as hypertension and liver cirrhosis (Gold et al., 2020; Rotevatn et al., 2017). Current literature presents a mixed picture of the negative health effects of alcohol consumption, irrespective of low, moderate, or high alcohol consumption levels (Rotevatn et al., 2017). While inherent risks exist for TKA patients intra- and post-operatively, limited research on the amount of alcohol consumption in the TKA population is available (Deng et al., 2021). Rotevatn et al. (2017) highlighted this knowledge gap and stressed that the lack of information on post-operative outcomes for low-moderate alcohol consumers may lead to misinterpreted data on morbidity and mortality rates. To enhance pre-operative risk management and gain a comprehensive understanding of the impact of alcohol on TKA patients, further research on this subject is deemed essential (Best et al., 2015).

Comorbidities.

Obesity.

Obesity is another increasingly prevalent comorbid condition. It can be classified into various groups based on Body Mass Index (BMI), which is calculated by dividing body weight in kilograms (kg) by height in meters squared (m^2; Bonnefoy-Mazure et al., 2017). A BMI under 18.5 is categorized as underweight, 18.5-24.9 as normal, 25.0-29.9 as overweight, and above 30.0 as obese. Furthermore, a BMI between 30.0-34.9 is class one obesity, 35.0-39.9 is class two obesity, and above 40 is class three (severe) obesity (Bonnefoy-Mazure et al., 2017; Podmore et al., 2018; Roth et al., 2019). BMI serves as a contributing factor in assessing prognosis following operations such as TKA procedures (Abdelmegied et al., 2020).

As the population experiences an increased overweight and obese population, concerns rise due to the heightened risk of developing knee OA. Abdelmegied et al. (2020) reported higher rates of infection and deep vein thrombosis in obese patients undergoing TKA. Being overweight or obese can lead to increased musculoskeletal strain, poor blood flow, and altered joint dynamics, resulting in poor mobility, decreased ROM, and a predisposition to developing other comorbidities (Bonnefoy-Mazure et al., 2017; Roth et al., 2019).

Notably, high BMI has been associated with increased blood loss, prolonged operative time, infection risk, likelihood of revision surgery, and low post-operative ROM (Bonnefoy-Mazure et al., 2017). Despite these associations, Abdelmegied et al. (2020) highlighted a lack of evidence depicting the recovery timeline and success of surgery in overweight or obese patients. Bonnefoy-Mazure et al. (2017) emphasized that severe obesity poses further challenges throughout TKA procedures, impacting pre- and post-operative outcomes, resulting in differences in gait and knee ROM compared to non-obese patients. Therefore, assessing patients with various BMI scores is crucial for a comprehensive understanding of the effect of obesity on TKA and recovery outcomes.

Functional Test Measures

Functional testing can be completed using physical performance tests. These tests were validated and used by the World Health Organization International Classification as an observational tool assessing physical function and the ability to perform ADL (Bennell et al., 2011). These measures, often involving timing, counting, or distance assessments, offer a standardized approach in healthcare settings to objectively evaluate an individual's capabilities, focusing on actual performance rather than perceived abilities (Bennell et al., 2011; Capin et al., 2022).

Bennell et al. (2011) emphasized that physical function directly correlates with an individual's capacity for movement and their ability to complete their ADL. Utilizing physical performance measures both pre-operatively and post-operatively significantly predicted function six months and 2 years following TKA (Capin et al., 2022). Notably, patients rarely meet age-matched normative scores for strength, function, and activity levels. Poor pre-operative performance in the SMWT, Stair Climb Test (SCT), and Stair Climb Power Test (SCPT) predicted poor performance in these measures six months post-TKA (Capin et al., 2022). Among the various functional tests used, strength and performance-based assessments targeting ADL stand out as crucial predictors of patients' ambulatory effectiveness and ability to regain independence (Capin et al., 2022). Consequently, incorporating physical performance measure assessments in both the prognosis and post-operative evaluation of TKA outcomes can provide valuable insights into factors influencing the success of the procedure (Bennell et al., 2011)

In comparison to self-reported instruments, performance-based measures not only exhibit greater sensitivity in tracking functional recovery but also demonstrate stronger associations with impairments beyond pain (Bennell et al., 2011; Capin et al., 2022; Ronai et al., 2019). Findings by Bennell and colleagues (2011) underscored the efficacy of performance-based measures, revealing small to medium associations with joint-specific legacy instruments while offering novel insights into their relationship with computerized adaptive testing instruments.

Stair Climb Test

The SCT stands out as a functional assessment placing substantial demand on the quadriceps muscle, measuring a higher level of function and minimizing the risk of a ceiling effect. Specifically designed to evaluate an individual’s capacity to ascend and descend a set of stairs, the SCT considers factors such as time taken for the task to be completed, use of assistive devices like railings or walking poles, and any modifications in movement during the test, providing a comprehensive insight into overall functional ability (Bennell et al., 2011).

Bennell et al. (2011) emphasized the SCT's utility in directly measuring stair usage ability, offering valuable information regarding limitations and rehabilitation for individuals with knee OA and those undergoing TKA. The SCT exhibited a strong correlation between OA and knee OA severity, as well as the success of surgical interventions (i.e., TKA), assessed through pre-operative and post-operative functioning (Bennell et al., 2011; Capin et al., 2022). Capin et al. (2022) further detailed how the SCT outcomes and muscle strength contributed to long-term success, with faster completion times indicating greater muscle strength and leading to more success at six-month follow-up post-TKA. Participants with longer completion times during the SCT, especially when coupled with the use of assistive devices, showed less successful outcomes at the six-month mark (Capin et al., 2022).

According to Bennell et al. (2011), the SCT exhibits a positive correlation with other physical performance measures (r =.59–.68), with its strongest association observed with the gait and speed of the individual. This test provides a direct assessment of how an individual navigates stairs, offering a true reference for understanding the impact of knee OA on participants (Bennell et al., 2011; Ronai et al., 2019).

Stair Climb Power Test

Functional measures before and after TKA play a crucial role in assessing outcomes related to power, endurance, and dynamic balance, providing valuable insights into the impact of OA and the effectiveness of TKA. Bennell et al. (2010) emphasized the significance of physical performance scores in accurately determining how OA affects patients and the potential outcomes of TKA. Among these measures, the SCPT is employed to evaluate lower extremity power (Ronai et al., 2020). Lower extremity power is defined as the rapid application of force during movement and may be assessed through the SCPT protocol, involving participants ascending a flight of 9-14 steps rapidly with/without the use of balance or assistive aids (Ronai et al., 2020). The test engages various muscles responsible for producing power in the vertical and horizontal planes, including the hip/knee extensors, ankle dorsiflexors, and plantarflexors (Holm et al., 2020; Ronai et al., 2020). Power can be defined as the rate at which work is done, or represented as an equation where watts (W) is calculated by work divided by time (Hussein et al., 2021)

The muscles most active in generating vertical and horizontal propulsive forces are the hip extensors and knee flexors, respectively. The completion of the SCPT recruits muscles such as the rectus femoris, vastus intermedius, vastus medialis, vastus lateralis, tibialis anterior, gastrocnemius, soleus, gluteus maximus, biceps femoris, semitendinosus, and semimembranosus (Ronai et al., 2020). These gross motor muscles are essential for successfully performing the SCPT. Ronai and colleagues (2020) reported that the time taken to ascend the flight of stairs in the SCPT correlates with overall lower extremity power, making it an accurate measure of power production. By engaging muscles both inferior and superior to the knee, as well as those surrounding the knee, the SCPT aligns with previous research, offering a reliable means to capture the limitations imposed by OA and the effects of TKA on outcomes (Holm et al., 2020).

Six-Minute Walk Test

The SMWT serves as a valuable tool to assess overall functional ability, cardiovascular health, endurance, and pain reproduction by measuring the distance walked in meters over a span of six minutes (French et al., 2010). According to Pourmoghaddam et al. (2016), the SMWT specifically evaluated endurance and the ability to walk long distances. Originally developed in 1963 as a test for physical fitness, it evolved into the 12-minute walk test and was later adapted to the six-minute version for assessing submaximal functional levels (Bennell et al., 2011).

With the aging population and the increasing prevalence of knee OA, research suggested a decline in functional capacity and cardiopulmonary function (Lin et al., 2012). Cardiopulmonary function refers to the difficulty an individual experiences while engaging in activity over an extended period, with endurance being its derivative. High endurance enables prolonged exercise. The SMWT, a field-based test, effectively measured endurance levels and provided inferences about cardiopulmonary function (Bennell et al., 2011; Holm et al., 2022; Lin et al., 2012). Participants walk on a standardized track or exercise location, attempting to cover as much distance as possible. The total distance walked is then correlated with a value in metabolic equivalents, indicating the individual's endurance capacity (Lin et al., 2012). Given its ability to assess endurance levels and pain reproduction, the SMWT is widely utilized for patients with impaired cardiovascular systems or progressive knee OA. Previous research suggests that functional test scores from the SMWT may be valuable in predicting the success of TKA for patients with end-stage knee OA (Bennell et al., 2011).

The SMWT, measuring the distance walked in six minutes, was reported to be among the most widely used performance-based tests (Bennell et al., 2011). Initially employed to evaluate endurance in patients with pulmonary disease, it has been validated for assessing functional mobility in various patient populations, including those undergoing TKA (French et al., 2010). The test exhibited excellent test-retest reliability (90%) and responsiveness to change after TKA, making it a safe, easy-to-administer, and well-tolerated tool (French et al., 2010; Bennell et al., 2011). Participants are allowed the use of an assistive device and are instructed to walk as quickly and safely as possible throughout the test.

Self-Assessment Measures

Lower Extremity Functional Scale

The Lower Extremity Functional Scale (LEFS) is a patient-reported self-assessment measure used to assess the ability to perform ADL (Turcotte et al., 2022). The LEFS has been reported to be a reliable, consistent, and dependable tool within orthopedic physical therapy settings since its introduction in 1999 (Turcotte et al., 2022). This 20-item self-report questionnaire, when applied to the assessments of musculoskeletal conditions affecting the lower extremities, has garnered attention in various studies (Naal et al., 2015; Repo et al., 2017; Turcotte et al., 2022). It is also useful as an objective measurement providing physical therapy progress, quality of life assurance, and functional status related to ADL (Naal et al., 2015; Turcotte et al., 2022).

According to Turcotte and colleagues (2022), the LEFS scale operates on a scoring system linked to the difficulty levels associated with each activity. Ranging from 0 (extreme difficulty/unable to perform the task) to 4 (no difficulty performing the task), the scores are then totaled, with a maximum score of 80 (Jogi et al., 2005; Naal et al., 2015). Higher scores, nearing 80, indicate a high degree of functioning with minimal difficulty, making the LEFS particularly applicable to patients grappling with lower extremity musculoskeletal disorders (Turcotte et al., 2022). Specifically, this tool was utilized in several instances to provide outcome measures for those undergoing TKA. Turcotte and colleagues (2022) research allowed for the evaluation of LEFS scores on patients who underwent TKA. Pre-operatively, the average LEFS was reported to be 36.3 ± 13.2, whereas post-operatively, it rose to 52.2 ± 12.6 across all total joint arthroplasties. Similar results were reported by Jogi and colleagues (2005) and Repo and colleagues (2017), affirming higher post-operative LEFS scores for all patients. Notably, those with higher pre-operative LEFS scores displayed decreased time to hospital discharge and exhibited enhanced physical function during follow-up sessions at six months and one year (Naal et al., 2015; Turcotte et al., 2022).

Despite the LEFS being recognized for its high reliability (r=.8-.9) in predicting pain and functional ability, a notable gap exists in the body of research with regard to reliable measures that can be used to predict functional outcomes; specifically concerning TKA (Naal et al., 2015; Repo et al., 2017; Turcotte et al., 2022). This underscores the need for future research to explore the predictive capacities of the LEFS on functional outcomes for patients undergoing TKA surgery.

Knee Injury and Osteoarthritis Outcome Score Survey

The Knee Injury and Osteoarthritis Outcome Score (KOOS) serves as a comprehensive self-report questionnaire designed to evaluate individuals' ADL, with a specific emphasis on knee injuries and knee OA to gauge functionality and monitor intervention outcomes (Christensen et al., 2023; Goncalves et al., 2010; Paradowski et al., 2015). Despite its widespread use, the KOOS has undergone modifications across different languages and countries. The most common English version encompasses four distinct subscales including symptoms (7 items), pain (9 items), function/daily living (17 items), and quality of life (4 items; Paradowski et al., 2015; Steinhoff et al., 2016). Research by Stevens-Lapsley and colleagues (2011) positioned the KOOS as an extension of the Western Ontario and McMaster Universities Arthritis Index, offering increased responsiveness and functionality for assessing patients with knee OA and pain. Notably, improvements in self-reported measures, including the KOOS, have shown a strong association with positive changes following interventions such as joint arthroplasty (Christensen et al., 2023).

Challenges, however, arose when individuals with progressive knee OA struggled to differentiate between being limited by pain or by functional ability as highlighted by Christensen and colleagues (2023) and Goncalves and colleagues. A shift in perspective is noted in the work of Steinhoff and colleagues, who initially questioned the KOOS's applicability but later found it to be a valuable tool in evaluating patient outcomes. Despite the reliance on self-report measures, they come with significant limitations, leading to potential over or underestimation of actual functional ability (Christensen et al., 2023; Steinhoff et al., 2016).

Goncalves and colleagues (2010) and Paradowski and colleagues echoed these sentiments, emphasizing that self-reported measures are essential for a comprehensive characterization of physical function. They argue that such measures should be used in conjunction with functional testing to facilitate a more thorough analysis of recovery in individuals undergoing TKA. In line with these perspectives, Stevens-Lapsley et al. (2011) reached similar conclusions in their research, indicating that the KOOS may not adequately reflect the magnitude of performance deficits after surgery. In conclusion, due to the scarcity of research exploring the predictive measures of the KOOS in tandem with functional testing in TKA, future studies should consider incorporating the KOOS alongside various functional test measures to assess its predictive characteristics.

Purpose of Research

TKA is an orthopedic surgical procedure designed to alleviate the effects of knee OA, aiming to enhance patients' strength, ROM, and ability to perform ADL post-operatively (Lin et al., 2021; Wellman et al., 2017). It is typically recommended when other non-surgical interventions have proven ineffective (Lin et al., 2021). Post-TKA, patients were anticipated to exhibit improved walking capacity, increased exercise tolerance, and enhanced abilities in ADL performance (Lin et al., 2021). The expectation was a progressive amelioration in patients' pain, function, and overall satisfaction following surgical discharge (Ozden & Tumturk, 2022). However, reports of pain and dissatisfaction at six-month and one-year post-operative follow-ups were becoming more prevalent (Ronai & Gallo, 2022).

The influence of lifestyle risk factors and comorbid conditions on TKA outcomes was a subject of increasing interest. Lifestyle factors like smoking and alcohol consumption were recognized as having detrimental effects on surgery and post-operative rehabilitation (Masaracchio et al., 2017). Patients with comorbidities, including obesity and diabetes, experienced poorer outcomes after TKA surgeries compared to those without these conditions (Roth et al., 2019). As the population of TKA patients with lifestyle risk factors and comorbidities continued to rise, understanding their impact on surgical outcomes became crucial (Bedard et al., 2017; Brock et al., 2017; Capin et al., 2017; Fansen et al., 2017).

The current body of research, however, did not provide concrete claims regarding whether specific lifestyle risk factors and comorbid conditions increased the risk of poorer recovery following TKA compared to patients without these conditions (Abdelmegied et al., 2021; Bonnefoy-Mazure et al., 2017; Brock et al., 2017). There was a lack of clarity on the precise impact of these factors on TKA outcomes. Additional research focused on understanding the risk factors that significantly influence whether TKA surgeries were warranted. Therefore, the primary objective of this study was to investigate the effect of lifestyle risk factors and the presence of comorbidities on both pre-operative and post-operative TKA patients, specifically evaluating their ability to perform functional tests. This research aimed to contribute to a more nuanced understanding of the complex interplay between lifestyle factors, comorbidities, and TKA outcomes, ultimately guiding improved patient care and management strategies.

Guiding Questions

The following questions were developed to guide this ongoing study:

1. Is there an effect of smoking status on pre- versus post-surgical functional performance measures, respectively?
   a) Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCT (time in s)?
   b) Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?
   c) Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SMWT (distance in m)?
2. Is there an effect of alcohol consumption status on pre- versus post-surgical functional performance measures, respectively?
   a) Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCT (time in s)?
   b) Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

c) Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

3. Is there an effect of comorbidities present on pre- versus post-surgical functional performance measures, respectively?

   a. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCT (time in s)?

   b. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

   c. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

4. Is there a relationship between BMI scores and pre-versus post-surgical functional performance measures, respectively?

   a) Is there a relationship between BMI scores and pre- versus post-surgical functional performance for the SCT (time in s)?

   b) Is there a relationship between BMI scores and pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

   c) Is there a relationship between BMI score and pre- versus post-surgical functional performance for the SMWT (distance in m)?

Chapter 2: Methodology

Participants

A total of 28 participants were recruited from Big Thunder Orthopedic Associates which services Thunder Bay and the region of Northwestern Ontario. Participants were recruited from patients scheduled to receive a TKA surgery. The number of required participants (34) for questions 1-3 was indicated by a priori power analysis. The sample size calculation included a large effect size value of .25, 80% power of rejection, and an alpha level set at .05. The number of required participants (38) for question 4 was indicated by a priori power analysis. The sample size calculation included a medium effect size value of .436, 80% power of rejection, and an alpha level set at .05.

Inclusion Criteria

Participants were included in this study if they were 18-85 years of age to represent the population with the highest incidence of TKA surgeries. Participants were required to be able to independently ambulate with or without an assistive device and be able to ascend/descend a flight of 14 steps. Participants were required to be proficient English speakers or have an interpreter present who was fluent in English during participation. It was required that participants were able to attend two separate testing visits at Lakehead University's School of Kinesiology which included one visit before surgery and six months following their TKA surgery.

Exclusion Criteria

Participants were excluded from the study if they had fractures, were receiving bilateral TKA surgery, or were expecting to receive revision surgery. Participants were required to be free of acute injuries that would affect their ability to complete the functional testing measures of the study.

Recruitment

Patients awaiting a TKA were notified of the current study by their surgeon at Big Thunder Orthopedic Associates. If patients expressed interest in participating in the study, they were asked by the Big Thunder Orthopedic Associates surgeon if they could be contacted by a member of the TBRHSC research team. Patients who agreed to be contacted by a member of the TBRHSC research team were informed and contacted by a student researcher attending Lakehead University's School of Kinesiology. Files were collected from patients who expressed interest in research participation and who consented to be contacted. Patient files were collected from Big Thunder Orthopedic Associates secretaries by the student researcher. Files collected by the student researcher were kept confidential and restricted providing only demographic information and contact information along with the scheduled surgical procedure. Prospective participants who displayed interest in participating in this study were contacted by the student researcher who discussed the details of the study using a provided phone script (see Appendix B). If prospective participants consented to participate, the student researcher organized a pre-operative visit that participants attended at Lakehead University's School of Kinesiology. The student researcher asked for additional contact information that was not provided on the participants' patient file such as an additional phone number or email address. The student researcher provided their contact information, including phone number and Lakehead University email along with the Lakehead University's School of Kinesiology address. The student researcher then explained to participants once they agreed to participate that they would be greeted at the main entrance of the designated building by the student researcher at the appointment date and time. Upon arrival, the student researcher directed the participant to Kinesiology lab SB-1028. The participant was sent all information before arrival to review if an email address was provided. If not, a thorough explanation of all functional test measures, self-assessment forms, and the participant's rights and requirements were described over the telephone. The participant once again had the same information presented in person with an emphasis placed on the voluntary nature of the study and that study withdrawal can occur at any time.

Psychometric Properties of Screening Measures and Instruments

Functional Test Measures

Stair Climb Test.

The SCT served as a functional evaluation, which assessed an individual's functional strength and balance during the process of ascending and descending a flight of stairs (Bennell et al., 2011). Sharma et al. (2023) reported that the SCT exhibited excellent test-retest reliability, with a high intraclass correlation coefficient (ICC) of .83. Furthermore, the test demonstrated robust construct validity, with an 83% agreement rate. This aligned with the findings of Bennell and colleagues (2011), who conducted tests on the SCT with individuals in the advanced stages of knee OA and reported a similarly high ICC of .90.

Additionally, Bennell et al.'s (2011) work involved 106 older adults with symptomatic hip and/or knee OA and found a strong correlation (*r*=.93) in a 5 or 9-step SCT over 2 weeks. However, when tested over 3 months, test-retest reliability showed a decrease (*r*=.75), suggesting the potential for true changes over this timeframe. Minimum detectable change (MDC) was determined by indicating the smallest change that was likely to be a true change beyond measurement error. Regarding measurement error, the SCT has been analyzed for MDC at 90% and/or standard error of measurement (SEM). The SCT demonstrated favourable correlations (*r*=.59–.68) with other physical performance measures, such as the Figure-8 Walk Test, gait speed, and Chair Rise Test, particularly following TKA. Notably, the SCT exhibited its strongest association with gait speed and its most minimal association with the Chair Rise Test (Bennell et al., 2011).

In summary, the SCT emerged as a reliable and valid measure for assessing functional strength and balance, with its effectiveness extending to individuals with knee OA and those undergoing knee arthroplasty. The test's sensitivity to changes over different periods and its correlation with various physical performance measures highlighted its versatility in clinical settings.

Stair Climb Power Test.

Almeida et al. (2010) assessed the SCPT and reported high reliability for both with an ICC of .94. The SEM for these tests was reported to be 1.14 s and .82 s, respectively. The MDC associated with a 90% confidence interval was found to be 2.6 s. Correlations between stair tests and various performance-based measures, as well as knee and hip muscle strength, were observed, with a moderate Pearson correlation coefficient (*r*=.40-.78). On the other hand, Ronai and Gallo (2022) reported excellent test-retest reliability for the SCPT (*r*=.99). The reliability demonstrated in both studies reinforced the dependability of stair-related tests for assessing physical function and power. However, differences in the specific tests and measurements used, highlighted the need for considering the nuances of each assessment tool in clinical and research contexts.

Six-Minute Walk Test.

French et al. (2010) established the test-retest reliability of the SMWT in patients with OA, indicating a high level of reliability (ICC=.94) and an SEM of 26.3 m. This reliability was further supported by a previous investigation with a similar group of subjects.

In contrast, Bennell et al. (2011) demonstrated the stability of the SMWT with high ICC ranging from .95-.97 in 96 community-dwelling elderly individuals (aged 61–89 years) with independent functioning. The measurement error, represented by the MDC at 90% confidence and/or SEM, was not explicitly mentioned in French et al.'s (2010) study but was a focus in Bennell et al.'s (2011) work.

Bennell et al. (2011) provided valuable insights into the predictive validity of pre-operative SMWT scores. These scores, along with knee pain and knee flexion ROM, were significant predictors (adjusted r=.66) of locomotor ability 2 months after knee arthroplasty. Additionally, evidence of responsiveness, and construct validity for endurance, strength, and function was demonstrated through correlations with various parameters, such as maximum oxygen consumption, and quadriceps/hamstring strength,

While both studies highlighted the reliability of the SMWT, Bennell et al. (2011) extended the understanding by emphasizing its predictive value and construct validity, providing a more comprehensive view of the test's utility in assessing functional outcomes in knee arthroplasty patients.

Self-Assessment Measures

Lower Extremity Functional Scale.

Naal and colleagues (2015) reported substantial reliability for the LEFS in their research, with an ICC of .98 and an SEM of 6.3%. Similarly, Turcotte and colleagues (2022) found the test-retest reliability of LEFS was excellent (*r*=.94), indicating high consistency over time. Turcotte and colleagues' (2022) results aligned closely with Naal and colleagues' (2015) findings regarding the reliability of the LEFS.

In addition to reliability, Turcotte et al. (2022) investigated sensitivity and specificity, and reported values of 91.7% and 68.9%, respectively. These metrics indicated the LEFS' ability to accurately identify true positives and negatives in assessing lower extremity function. Naal and colleagues (2015) also contributed to the construct validity of the LEFS by demonstrating large to very large correlations (*r*=.52-.91). Saleh and colleagues (2005) supported these findings; they reported a significant correlation for LEFS scores with a Pearson correlation of (*r*=.715). Additionally, Saleh et al. (2005) highlighted the significant test-retest correlation (*r*=.9147), which reinforced the validity and reliability of the LEFS survey.

Repo and colleagues (2017) confirmed the high internal consistency of LEFS; they reported high test-retest reliability (ICC=.93) and a SEM of 4.1 points. These results further supported the reliability and consistency of the LEFS scale. Kennedy and colleagues (2008) recorded a slightly lower test-retest reliability (.85). However, the test remained within the high-reliability range, suggesting that the LEFS scale was indeed a reliable self-assessment measure with MDC being 9 scale points (Binkley et al., 1999). The overall body of research consistently supported the reliability, validity, and consistency of the LEFS in assessing lower extremity function.

Knee Injury and Osteoarthritis Outcome Score.

The KOOS survey has consistently demonstrated excellent reliability and adequate content and construct validity for both short- and long-term follow-up of knee injuries, including knee OA (Christensen et al., 2023). Its applicability extended to patients with knee OA and those undergoing or having undergone TKA, which made it a versatile evaluation tool (Steinhoff & Bugbee, 2016; Stevens-Lapsley et al., 2011).

In studies conducted by Christensen et al. (2023) and Goncalves et al. (2010), the KOOS survey exhibited high test-retest reliability; Christensen et al. (2023) reported reliability values ranging from .75-.91 and Goncalves et al. (2010) supported these findings with reliability values between .70-.95. Paradowski and colleagues (2015) utilized a two-way random effect model of the ICC for absolute agreement and reported ICC values exceeding .90 for individual patient use, which indicated excellent reliability. Steinhoff and Bugbee (2016) further supported these outcomes, reinforcing the high reliability of the KOOS survey.

The test-retest reliability at follow-up was consistently excellent, as reported by Paradowski et al. (2015), with ICCs ranging from .81-.86 for all KOOS subscales. The MDC ranged from 18.2-24.3 on an individual level and from 2.4-2.9 on a group level. These findings provided additional evidence of the reliability and sensitivity of the KOOS over time. Goncalves and colleagues (2010) recorded an ICC of .85, which further certified that the reliability of KOOS was acceptable for assessing knee function in various populations. Overall, the KOOS survey consistently demonstrated robust reliability and validity, which made it a valuable tool for assessing knee injury and OA outcomes.

Procedures

Data Collection

Following telephone contact with prospective participants using the provided phone script (see Appendix B), an appointment date was provided for testing. Participants arrived at the main entrance of the Sanders Building located at Lakehead University's School of Kinesiology. The participant was greeted at the main entrance where they then were escorted to Kinesiology lab SB-1028. Within the Kinesiology lab, the participant was informed about all details of the study, the rights and requirements of the participant, and the voluntariness of the study. The participant was provided with the information form (see Appendix C) which described why the study was being done, the benefits to society, and the requirements of the study. Additionally, the participant was informed of the information being collected, risks/harms of participation, participation benefits, participant incentives, early withdrawal, and research-related injuries. Finally, the participant was informed about confidentiality, conflict of interests, COVID-19 protection, and who to contact for questions and problems. The consent form was provided for the participant (see Appendix D) to read and sign after all questions and concerns were thoroughly answered. If the participant declined to sign the consent form, participation in the study was terminated and the participant was escorted back to the main entrance of the building ensuring transportation arrived and reimbursement was provided for parking. If the participant thoroughly read and signed the consent form, participation in the study commenced.

Case Report Form.

Questions provided on the case report form (see Appendix E) were completed once informed consent was provided and signed. Participants were asked their date of birth, age, and sex followed by having their height (cm) and body mass (kg) measured and recorded. BMI of the participant was calculated and recorded. The participant was asked about their smoking status (i.e., every day, some days, former, never, or unknown), and alcohol consumption (i.e., daily, occasionally, never, or unknown). Additionally, the participant was asked if/what comorbidities are present (i.e., diabetes, history of cancer, hypertension cardiovascular conditions, pulmonary conditions, prior stroke(s), and/or other). The participant was asked about the geographical location in which they reside (i.e., Thunder Bay, Northwestern Ontario, Outside of Northwestern Ontario, or Unknown). Additionally, the participant confirmed that they were receiving a unilateral TKA, which leg was being operated on, and if a surgery date had been provided.

Lower Extremity Functional Scale.

The participant was informed that the LEFS (see Appendix F) was to be completed next. The participant was provided a questionnaire that consisted of 20 questions and was instructed to answer what degree of difficulty they had or would have had with the presented activities within the last week. Participants were instructed to answer a series of questions on a Likert scale ranging from zero to four. The range of ability was between zero representing extreme difficulty/unable to perform the activity and four representing no difficulty. The total score was added, and the value was recorded out of 80.

Knee Injury and Osteoarthritis Outcome Score Survey.

The participant was asked to complete the KOOS survey (see Appendix G) next. This survey provided questions in four separate sections which included questions related to the symptoms (7), pain (9), function/daily living (17), and quality of life (4), respectively. If the participant had any questions or concerns about the presented questions within the survey, then the participant was provided the best possible clarification.

Stair Climb Test.

The participant was informed that the SCT would be completed next. The participant was directed to the eastern stairwell of the building followed by turning on all lights, placing two orange cones at the top and bottom of the stairwell, followed by moving two chairs at the top and bottom of the stairwell. The participant was informed that there are rubber steps to prevent slipping, railings on both sides of the stairwell, and chairs placed at the top and bottom of the stairwell with orange cones marking the testing area. Additionally, the participant was informed that they would be guided through the test simultaneously for additional safety. The participant was instructed to descend and stand at the bottom of the stairwell marked by two orange cones before testing. The participant was informed that they can use the railings and any personal assistive devices, if needed, to complete the test. On the command "Go", the participant was instructed to ascend and descend the flight of 14 steps as fast as possible with safety being the primary objective. The participant was informed that the time will stop when both feet reach the bottom platform. The participant was informed that they can rest/stop at any point of the test if required. If the participant begins the test and cannot finish due to the risk of injury, fatigue, or pain, the test was concluded and was not re-administered. Upon the completion of the SCT, the time (s) taken to complete the test was recorded and if any assistive devices were used.

Stair Climb Power Test.

The participant remained in the same testing area as the previous test due to the same area and equipment being used. Additionally, the participant was informed about the same safety measures and precautions as the SCT which had been previously completed before the SCPT. The participant was instructed to stand at the bottom of the stairwell marked by two orange cones. The participant was informed that they can use the railings and any personal assistive devices if needed. On the command “Go”, the participants were instructed to ascend the flight of 14 steps as fast as possible with safety being the primary objective. The participant was informed that the time will stop when both feet reach the top platform. The participant was informed that they can rest/stop at any point of the test. If the participant began the test and could not finish due to the risk of injury or fatigue, the test was concluded and would not be re-administered. Upon the completion of the SCPT, the time (s) taken to complete the test was recorded. The average power output (W) was calculated and recorded throughout the test by using the participant’s body mass (kg) multiplied by the force of gravity (m/s^2), multiplied by the height of the stairwell (m), and divided by time to completion (s).

Six-Minute Walk Test.

The participant was informed that they would move onto the oval track located in the hanger after adequate rest had been given following the previously administered tests. The participant was instructed that they can either descend the stairwell or take an elevator to the next testing location. The participant had the opportunity to rest on placed chairs and benches, if needed, on route to the next testing location. Upon arrival at the next testing location, the participant was instructed to sit and wait in a chair in the designated rest area. Two orange cones were placed in the first inside lane of the oval track followed by one chair every 50 m. The participant was instructed to stand on the marked starting line presented on the oval track in lane one which is indicated by orange cones. The participant was instructed to walk as fast as possible in their designated lane on the signal “Go”. The participant was instructed that the test will last 6 minutes regardless of the time taken for rest. The participant as also informed that spotter will carry a chair during the test for additional safety. The participant was informed that they can rest/stop at any point of the test. If the participant began the test and could not finish due to the risk of injury or fatigue, the test was concluded and was not re-administered. Upon completion of the SMWT, the distance walked (m) was recorded and if any assistive devices were used. The participant was then escorted back to the main entrance of the building after adequate rest was provided reimbursement for parking, answered and clarified any questions or concerns, and then concluded the first testing session.

Data Analysis

Data analysis was completed using reported lifestyle risk factors and comorbidities along with functional test measure scores which were recorded at the initial testing session (pre-surgery) and six-month follow up (post-surgery). Collected data was exported and categorized into Microsoft® Excel for primary analysis. Statistical analysis was completed with IBM® SPSS® 29.

Question 1 was answered using a two-way mixed factorial analysis of variance (ANOVA) that determined if there was an effect of smoking status on pre- versus post-surgical functional performance measures, respectively. Question 2 was answered using a two-way mixed factorial ANOVA that determined if there was an effect of alcohol consumption status on pre- versus post-surgical functional performance measures, respectively. Question 3 was answered using a two-way mixed factorial ANOVA that determined if there was an effect of comorbidities present on pre- versus post-surgical functional performance measures, respectively. Question 4 was answered using a bivariate correlational analysis that determined if there was a relationship between BMI score on pre-versus post-surgical functional performance measures, respectively.

To address question 1, smoking status was categorized into two groups (smoker/former smoker versus non-smoker) and was assessed over two conditions (pre- versus post-surgery) on the SCT (time in s), SCPT (time in s and power in W) and SMWT (distance in m), respectively.

To address question 2, alcohol consumption was categorized into two groups (drinkers versus non-drinkers) and was assessed over two conditions (pre- versus post-surgery) on the SCT (time in s), SCPT (time in s and power in W) and SMWT (distance in m), respectively. To address question 3, comorbidities present were categorized into two groups (≤ 1 versus ≥ 2) and were assessed over two conditions (pre- versus post-surgery) on the SCT (time in s), SCPT (time in s and power in W) and SMWT (distance in m), respectively. To address question 4, BMI scores were compared against two conditions (pre- versus post-surgery) on the SCT, SCPT, and SMWT, respectively.

Chapter 3: Results

This study aimed to investigate the effect of lifestyle risk factors and the presence of comorbidities on both pre-operative and post-operative TKA patients, specifically evaluating their ability to perform functional tests. A total of 28 participants completed the study which included 12 males, and 16 females as displayed in Table 1.

Table 1.

Demographic Characteristics of Participants

Sex (N)	Mean Age	Mean BMI (kg/m^2)	Smoking Status	Alcohol Consumption Status	Comorbidities Present
Males (12)	68.5	36.90	Smokers/Former Smokers = 8 Non-Smokers = 4	Drinkers = 9 Non-Drinkers = 3	≤ 1 Comorbidity = 7 ≥ 2 Comorbidities = 5
Females (16)	72.5	32.65	Smokers/Former Smokers = 3 Non-Smokers = 13	Drinkers = 11 Non-Drinkers = 5	≤ 1 Comorbidity = 9 ≥ 2 Comorbidities = 7

Note. This table displays the descriptive statistics for smoking status and functional test scores.

Question #1: Is there an effect of smoking status on pre- versus post-surgical functional performance measures, respectively?

Descriptive statistics indicated that for smoking status, non-smokers recorded the lowest mean time and power on the SCT (s), SCPT (s), and SCPT (W) and highest mean distance on the SMWT (m) compared to smokers/former smokers, both pre- and post-operatively (see Table 2). A homogeneity of error variance test was conducted, and based on Levene's Test, there were no violations of homogeneity of variance (p>.05) as displayed in Appendix H.

Inferential statistics via a two-way mixed factorial ANOVA was conducted with the independent variables being smoking status (smokers/former smokers versus non-smokers) and time (pre- and post-operatively). Dependent variables were functional test scores (SCT, SCPT, and SMWT). This analysis was conducted to examine the interactions and main effects between the smoking status and time for the functional test measure outcomes.

Table 2.

Descriptive Statistics for Smoking Status and Functional Test Measures

	Smoking Status	N	Mean	Std. Deviation	Std. Error Mean
Stair Climb Test Pre-Surgery (s)	Smoker/Former Smoker	11	36.79	14.26	4.30
	Non-Smoker	17	33.36	14.58	3.53
Stair Climb Test Post-Surgery (s)	Smoker/Former Smoker	11	24.09	9.52	2.87
	Non-Smoker	17	23.08	7.42	1.80
Stair Climb Power Test Pre-Surgery (s)	Smoker/Former Smoker	11	14.66	6.11	1.84
	Non-Smoker	17	12.91	4.97	1.20
Stair Climb Power Test Post-Surgery (s)	Smoker/Former Smoker	11	10.39	3.72	1.12
	Non-Smoker	17	9.97	2.63	.63
Stair Climb Power Test Pre-Surgery (W)	Smoker/Former Smoker	11	236.63	135.18	40.75
	Non-Smoker	17	184.90	79.04	19.17
Stair Climb Power Test Post-Surgery (W)	Smoker/Former Smoker	11	298.43	133.67	40.30
	Non-Smoker	17	226.81	93.01	22.56
Six Minute Walk Test Pre-Surgery (m)	Smoker/Former Smoker	11	295.54	100.89	30.42
	Non-Smoker	17	372.35	85.96	20.84
Six Minute Walk Test Post-Surgery (m)	Smoker/Former Smoker	11	400.09	92.03	27.74
	Non-Smoker	17	426.82	71.76	17.40

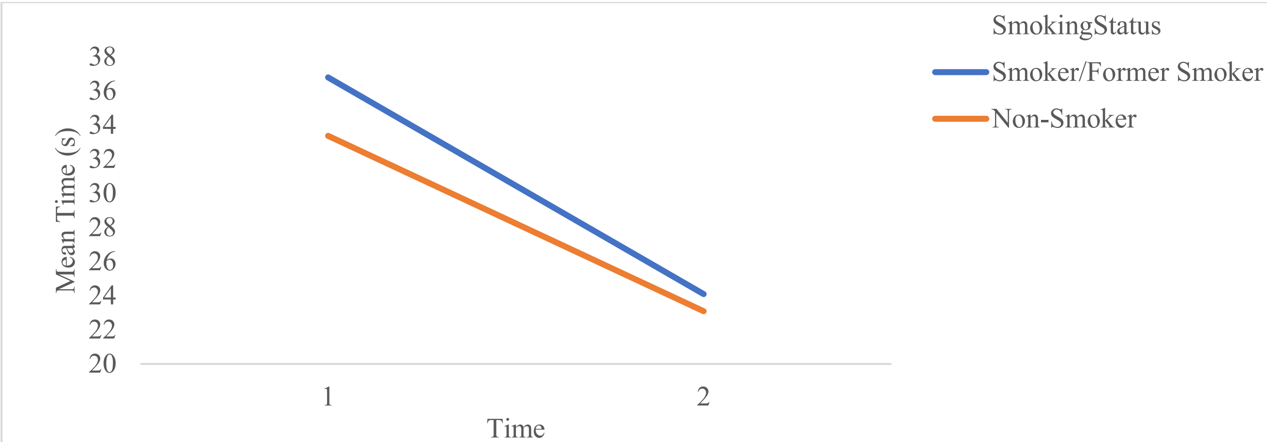
Note. This table displays the descriptive statistics for smoking status and functional test scores.

a. Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCT (time in s)?

There was no statistically significant interaction effect between smoking status and time for SCT (s) as displayed in Figure 1 (see Appendix H), $F(1,26)=.27$, $p>.05$, $\eta^2=.01$. There was no statistically significant main effect for smoking status on the SCT (s) as displayed in Figure 1 (see Appendix H), $F(1,26)=.31$, $p>.05$, $\eta^2=.01$. There was, however, a statistically significant main effect for time with a large effect size on the SCT (s) with a decrease in time (s) for smokers/former smokers and non-smokers post-operatively as displayed in Figure 1 (see Appendix H), $F(1,26)=24.73$, $p<.05$, $\eta^2=.48$.

Figure 1.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCT (s)



Note. This figure displays the estimated marginal means of measure for the SCT (s) pre- and 6-months post-surgery.

b. Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

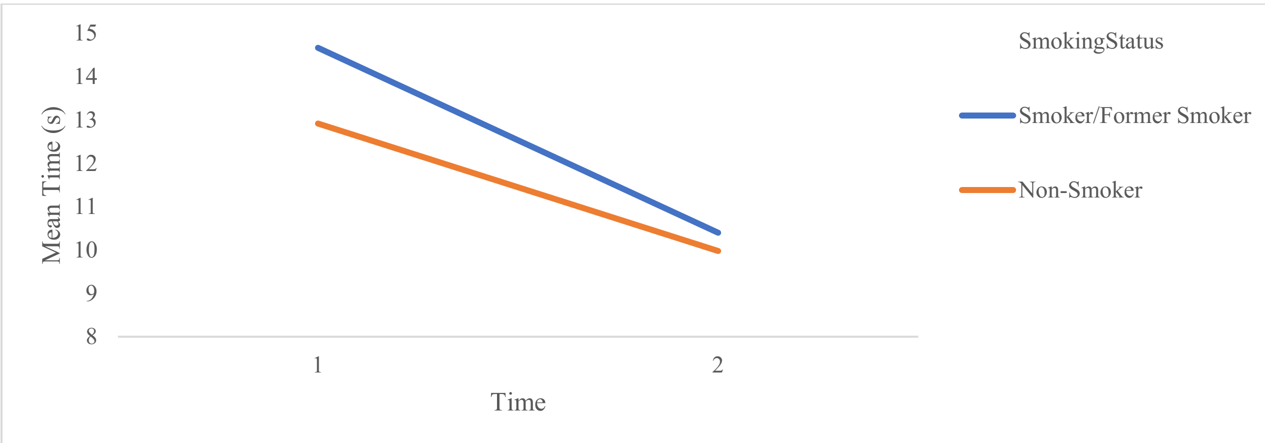
There was no statistically significant interaction effect between smoking status and time on the SCPT (s) as displayed in Figure 2 (see Appendix H), $F(1,26)=.59$, $p>.05$, $\eta^2=.02$. There was no statistically significant main effect for smoking status on the SCPT (s) as displayed in Figure 2 (see Appendix H), $F(1,26)=.53$, $p>.05$, $\eta^2=.02$. There was a statistically significant main effect for time with a large effect size on the SCPT (s) with a decrease in time (s) for smokers/former smokers and non-smokers post-operatively as displayed in Figure 1 (see Appendix H), $F(1,26)=17.66$, $p<.05$, $\eta^2=.40$.

There was no statistically significant interaction effect between smoking status and time on the SCPT (W) as displayed in Figure 3 (see Appendix H), $F(1,26)=.63$, $p>.05$, $\eta^2=.02$. There was no statistically significant main effect for smoking status on the SCPT (W) as displayed in Figure 3 (see Appendix H), $F(1,26)=2.42$, $p>.05$, $\eta^2=.08$. There was a statistically significant main effect for time with a large effect size on the SCPT (W) with an increase in power output

(W) for smokers/former smokers and non-smokers post-operatively as displayed in Figure 3 (see Appendix H), $F(1,26)=17.14$, $p<.05$, $\eta^2=.39$.

Figure 2.

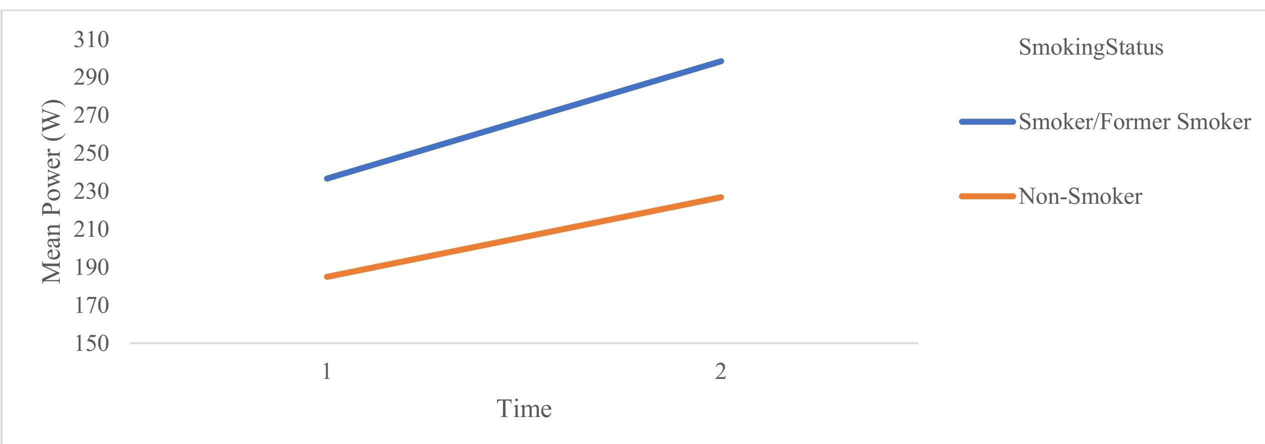
Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCPT (s)



Note. This figure displays the estimated marginal means of measure for the SCPT (s) pre- and 6-months post-surgery.

Figure 3.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SCPT (W)



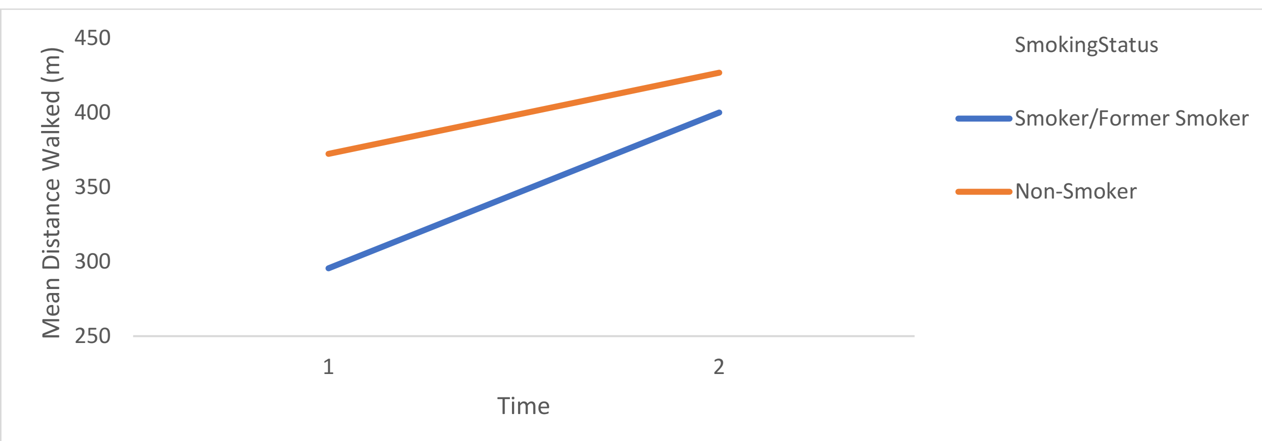
Note. This figure displays the estimated marginal means of measure for the SCPT (W) pre- and 6-months post-surgery.

c. Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

There was no statistically significant interaction effect between smoking status and time SMWT (m) as displayed in Figure 4 (see Appendix H), $F(1,26)=2.03$, $p>.05$, $\eta^2=.07$. There was no statistically significant main effect for smoking status on the SMWT (m) as displayed in Figure 4 (see Appendix H), $F(1,26)=3.32$, $p>.05$, $\eta^2=.11$. There was a statistically significant main effect for time with a large effect size on the SMWT (m) with an increase in distance walked (m) for smokers/former smokers and non-smokers post-operatively as displayed in Figure 4 (see Appendix H), $F(1,26)=20.54$, $p<.05$, $\eta^2=.44$.

Figure 4.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SMWT (m)



Note. This figure displays the estimated marginal means of measure for the SMWT (m) pre- and 6-months post-surgery.

Question #2: Is there an effect of alcohol consumption status on pre- versus post-surgical functional performance measures, respectively?

Descriptive statistics indicated that for alcohol consumption status, non-drinkers recorded the lowest mean time for the SCT (s), SCPT (s; pre- and post-operatively), and distance for the SMWT (m; post-operatively) compared to drinkers (see Table 3). Non-drinkers recorded the highest mean power on the SCPT (W; pre- and post-operatively) and distance on the SMWT (m; post-operatively) compared to drinkers (see Table 3). A homogeneity of error variance test was conducted, and based on Levene's Test, there were insignificant results (p>.05) displayed in Appendix I.

Inferential statistics via two-way mixed factorial ANOVA was conducted with the independent variables being alcohol consumption status (drinkers versus non-drinkers) and time (pre- versus post-operatively. Dependent variables were functional test scores (SCT, SCPT, and SMWT) pre- and post-operatively. This analysis was conducted to examine the interaction and main effects between alcohol consumption status and time for functional test measure outcomes.

Table 3.

Descriptive Statistics for Alcohol Consumption Status and Function Test Measures

	Alcohol Consumption Status	N	Mean	Std. Deviation	Std. Error Mean
Stair Climb Test Pre-Surgery (s)	Drinker	20	35.15	14.83	3.31
	Non-Drinker	8	33.62	13.73	4.85
Stair Climb Test Post-Surgery (s)	Drinker	20	24.25	8.82	1.97
	Non-Drinker	8	21.54	6.23	2.20
Stair Climb Power Test Pre-Surgery (s)	Drinker	20	14.03	5.54	1.23
	Non-Drinker	8	12.52	5.25	1.85
Stair Climb Power Test Post-Surgery (s)	Drinker	20	10.32	3.15	.70
	Non-Drinker	8	9.68	2.91	1.03
Stair Climb Power Test Pre-Surgery (W)	Drinker	20	194.15	75.52	16.88
	Non-Drinker	8	232.92	161.96	57.26
Stair Climb Power Test Post-Surgery (W)	Drinker	20	244.07	87.28	19.51
	Non-Drinker	8	282.12	168.33	59.51
Six Minute Walk Test Pre-Surgery (m)	Drinker	20	345.75	101.51	22.70
	Non-Drinker	8	333.25	94.66	33.47
Six Minute Walk Test Post-Surgery (m)	Drinker	20	409.75	81.43	18.20
	Non-Drinker	8	432.75	78.25	27.66

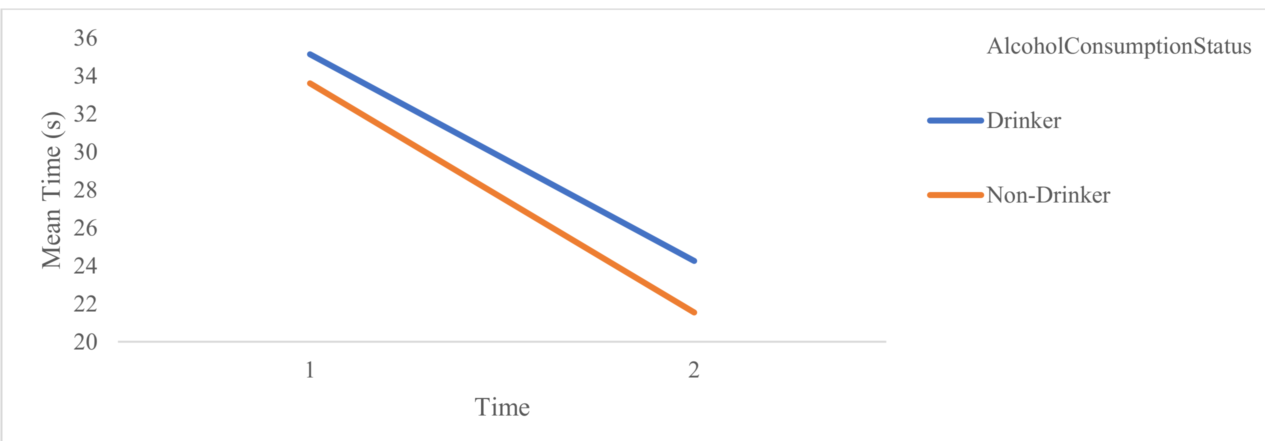
Note. This table displays the descriptive statistics for alcohol consumption status and functional test measures.

a. Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCT (time in s)?

There was no statistically significant interaction effect between alcohol consumption status and time on SCT (s) as displayed in Figure 5 (see Appendix I), $F(1,26)=.05$, $p>.05$, $\eta^2<.01$. There was no statistically significant main effect for alcohol consumption status on the SCT (s) as displayed in Figure 5 (see Appendix I), $F(1,26)=.24$, $p>.05$, $\eta^2<.01$. There was a statistically significant main effect for time with a large effect size on the SCT (s) with a decrease in time (s) for drinkers and non-drinkers post-operatively as displayed in Figure 5 (see Appendix I), $F(1,26)=20.96$, $p<.05$, $\eta^2=.44$.

Figure 5.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCT (s)



Note. This figure displays the estimated marginal means of measure for the SCT (s) pre- and 6-months post-surgery.

b. Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

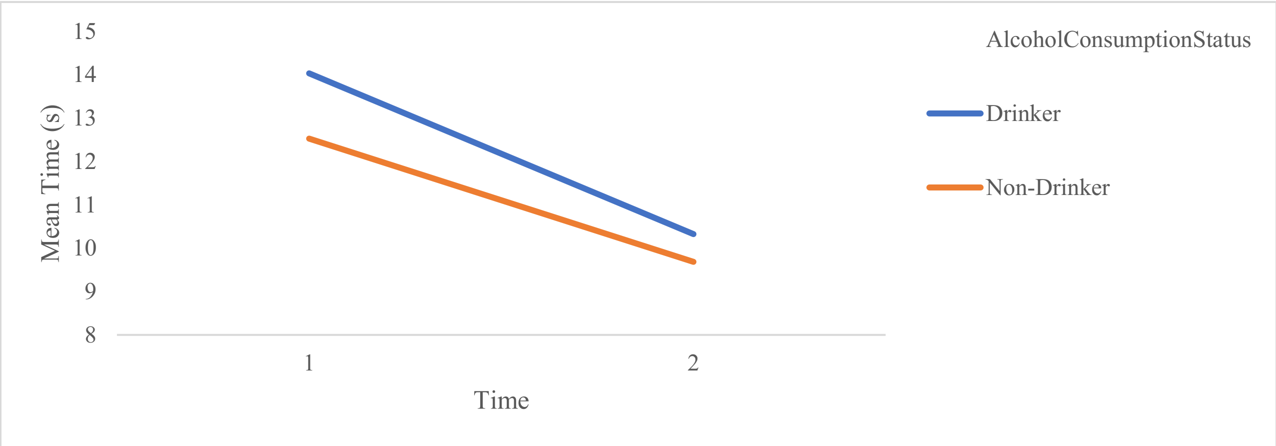
There was no statistically significant interaction effect between alcohol consumption status and time on the SCPT (s) as displayed in Figure 6 (see Appendix I), $F(1,26)=.21$, $p>.05$, $\eta^2<.01$. There was no statistically significant main effect for alcohol consumption status on the

SCPT (s) as displayed in Figure 6 (see Appendix I), $F(1,26)=.44$, $p>.05$, $\eta^2=.01$. There was a statistically significant main effect for time with a large effect size on the SCPT (s) with a decrease in time (s) for drinkers and non-drinkers post-operatively as displayed in Figure 6 (see Appendix I), $F(1,26)=12.30$, $p<.05$, $\eta^2=.32$.

There was no statistically significant interaction effect between alcohol consumption status and time on the SCPT (W) as displayed in Figure 7 (see Appendix I), $F(1,26)=.00$, $p>.05$, $\eta^2<.01$. There was no statistically significant main effect for alcohol consumption status on the SCPT (W) as displayed in Figure 7 (see Appendix I), $F(1,26)=.75$, $p>.05$, $\eta^2=.02$. There was a statistically significant main effect for time with a large effect size on the SCPT (W) with an increase in power output (W) for drinkers and non-drinkers post-operatively as displayed in Figure 7 (see Appendix I), $F(1,26)=13.09$, $p<.05$, $\eta^2=.33$.

Figure 6.

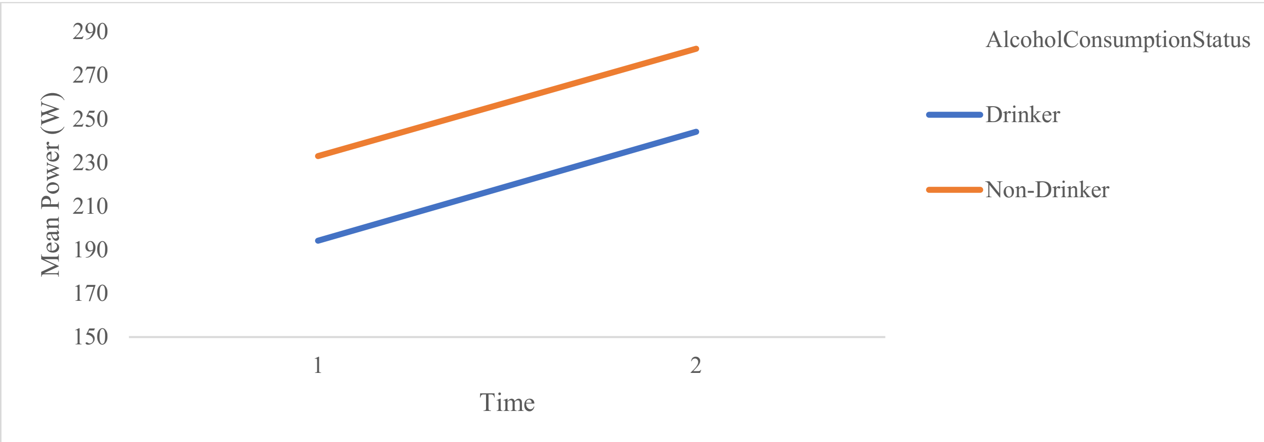
Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SCPT (s)



Note. This figure displays the estimated marginal means of measure for the SCPT (s) pre- and 6-months post-surgery.

Figure 7.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SCPT (W)



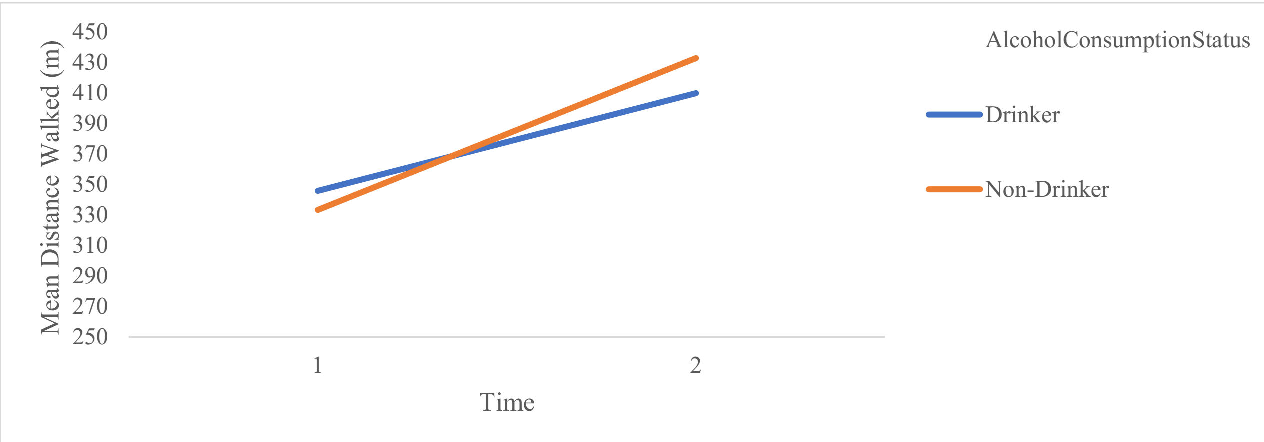
Note. This figure displays the estimated marginal means of measure for the SCPT (s) pre- and 6-months post-surgery.

c. Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

There was no statistically significant interaction effect between alcohol consumption status and time on the SMWT (m) as displayed in Figure 8 (see Appendix I), $F(1,26)=.83$, $p>.05$, $\eta^2=.03$. There was no statistically significant main effect for alcohol consumption status on the SMWT (m) as displayed in Figure 8 (see Appendix I), $F(1,26)=.02$, $p>.05$, $\eta^2<.01$. There was a statistically significant main effect for time with a large effect size on the SMWT (m) with an increase in distance walked (m) for drinkers and non-drinkers post-operatively as displayed in Figure 8 (see Appendix I), $F(1,26)=17.78$, $p<.05$, $\eta^2=.40$.

Figure 8.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SMWT (m)



Note. This figure displays the estimated marginal means of measure for the SMWT (m) pre- and 6-months post-surgery.

Question #3: Is there an effect of comorbidities present on pre- versus post-surgical functional performance measures, respectively?

Descriptive statistics indicated that participants with ≤ 1 comorbidity recorded the lowest mean time on the SCT (s; pre- and post-operatively) and SCPT (s; pre-operatively) compared to participants with ≥ 2 comorbidities (see Table 4.) Participants with ≤ 1 comorbidity recorded the highest mean time, power, and distance on the SCPT (s; post-operatively), SCPT (W; pre- and post-operatively), and SMWT (m; pre- and post-operatively) respectively, as displayed in Table 4. A homogeneity of error variance test was conducted, and based on Levene's Test, there were no violations of homogeneity of variance (p>.05) displayed in Appendix J.

Inferential statistics via two-way mixed factorial ANOVA was conducted with the independent variable being comorbidities present (≤ 1 versus ≥ 2 comorbidities) and time (pre- and post-operatively). Dependent variables were functional test scores (SCT, SCPT, and SMWT) pre- and post-operatively. This analysis was conducted to examine the interactions and main effects between comorbidities present and functional test measure outcomes.

Table 4.

Descriptive Statistics for Comorbidities Present and Functional Test Measures

	Comorbidities Present	N	Mean	Std. Deviation	Std. Error Mean
Stair Climb Test Pre-Surgery (s)	≤ 1 Comorbidity	17	32.33	13.94	3.38
	≥ 2 Comorbidities	11	38.38	14.69	4.43
Stair Climb Test Post-Surgery (s)	≤ 1 Comorbidity	17	23.38	9.15	2.22
	≥ 2 Comorbidities	11	23.63	6.73	2.03
Stair Climb Power Test Pre-Surgery (s)	≤ 1 Comorbidity	17	12.96	5.78	1.40
	≥ 2 Comorbidities	11	14.58	4.86	1.46
Stair Climb Power Test Post-Surgery (s)	≤ 1 Comorbidity	17	10.18	3.64	.88
	≥ 2 Comorbidities	11	10.07	1.95	.58
Stair Climb Power Test Pre-Surgery (W)	≤ 1 Comorbidity	17	215.35	122.77	29.77
	≥ 2 Comorbidities	11	189.58	74.16	22.36
Stair Climb Power Test Post-Surgery (W)	≤ 1 Comorbidity	17	256.04	138.32	33.54
	≥ 2 Comorbidities	11	253.26	67.21	20.26
Six Minute Walk Test Pre-Surgery (m)	≤ 1 Comorbidity	17	374.29	85.07	20.63
	≥ 2 Comorbidities	11	292.54	99.49	30.00
Six Minute Walk Test Post-Surgery (m)	≤ 1 Comorbidity	17	433.94	81.47	19.76
	≥ 2 Comorbidities	11	389.09	72.27	21.79

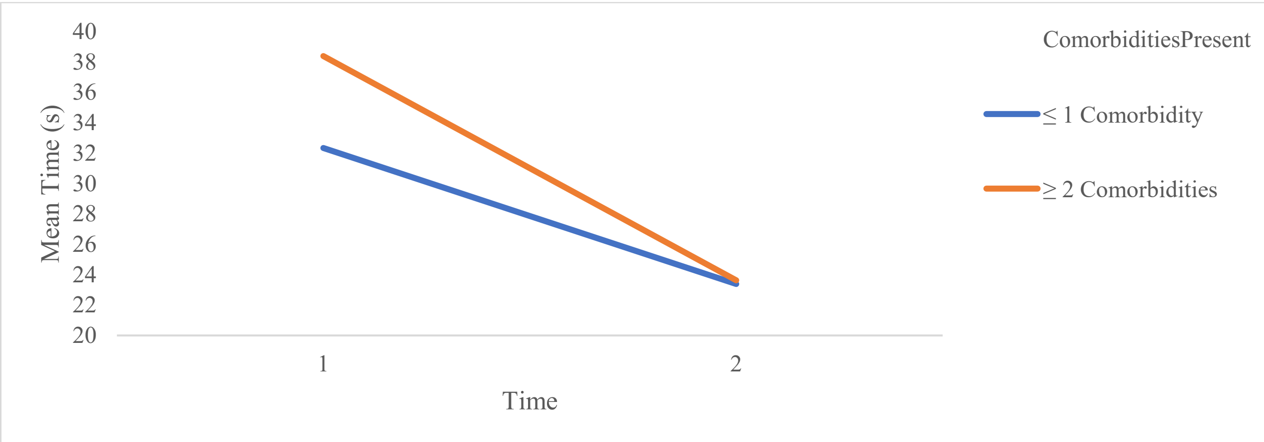
Note. This table displays the descriptive statistics for comorbidities present and functional test measures.

a. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCT (time in s)?

There was no statistically significant interaction effect between comorbidities present and time on the SCT (s) as displayed in Figure 9 (see Appendix J), $F(1,26)=1.66$, $p>.05$, $\eta^2=.06$. There was no statistically significant main effect for comorbidities present on the SCT (s) as displayed in Figure 9 (see Appendix J), $F(1,26)=.64$, $p>.05$, $\eta^2=.02$. There was a statistically significant main effect for time with a large effect size on the SCT (s) with a decrease in time (s) for participants presenting with ≤ 1 and ≥ 2 comorbidities as displayed in Figure 9 (see Appendix J), $F(1,26)=27.71$, $p<.05$, $\eta^2=.51$.

Figure 9.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCT (s)



Note. This figure displays the estimated marginal means of measure for the SCT (s) pre- and 6-months post-surgery.

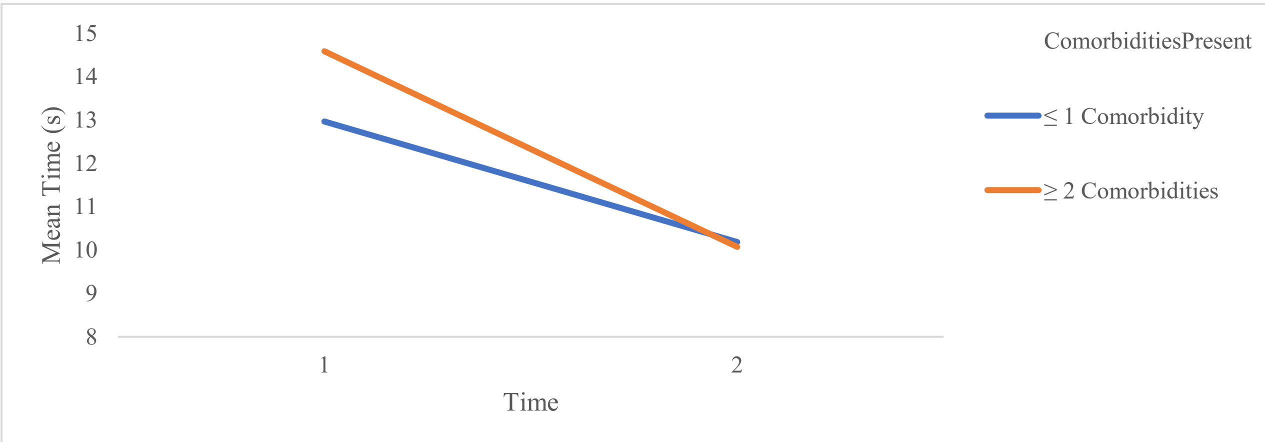
b. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

There was no statistically significant interaction effect between comorbidities present and time on the SCPT (s) as displayed in Figure 10 (see Appendix J), $F(1,26)=1.03$, $p>.05$, $\eta^2=.03$. There was no statistically significant main effect for comorbidities present on the SCPT (s) as displayed in Figure 10 (see Appendix J), $F(1,26)=.22$, $p>.05$, $\eta^2=.01$. There was a statistically significant main effect for time with a large effect size on the SCPT (s) with a decrease in time (s) for participants presenting with ≤ 1 and ≥ 2 comorbidities as displayed in Figure 10 (see Appendix J), $F(1,26)=18.38$, $p<.05$, $\eta^2=.41$.

There was no statistically significant interaction effect between comorbidities present and time on the SCPT (W) as displayed in Figure 11 (see Appendix J), $F(1,26)=.85$, $p>.05$, $\eta^2=.03$. There was no statistically significant main effect for comorbidities present on the SCPT (W) as displayed in Figure 11 (see Appendix J), $F(1,26)=.11$, $p>.05$, $\eta^2<.01$. There was a statistically significant main effect for time with a large effect size on the SCPT (W) with an increase in power output (W) for participants presenting with ≤ 1 and ≥ 2 comorbidities as displayed in Figure 11 (see Appendix J), $F(1,26)=17.51$, $p<.05$, $\eta^2=.40$.

Figure 10.

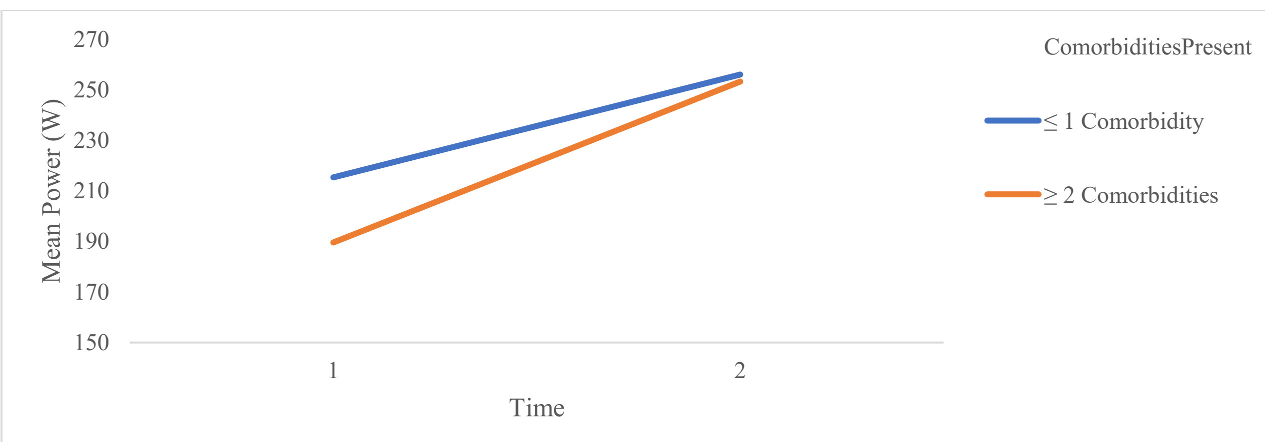
Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCPT (s)



Note. This figure displays the estimated marginal means of measure for the SCPT (s) pre- and 6-months post-surgery.

Figure 11.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for the SCPT (W)



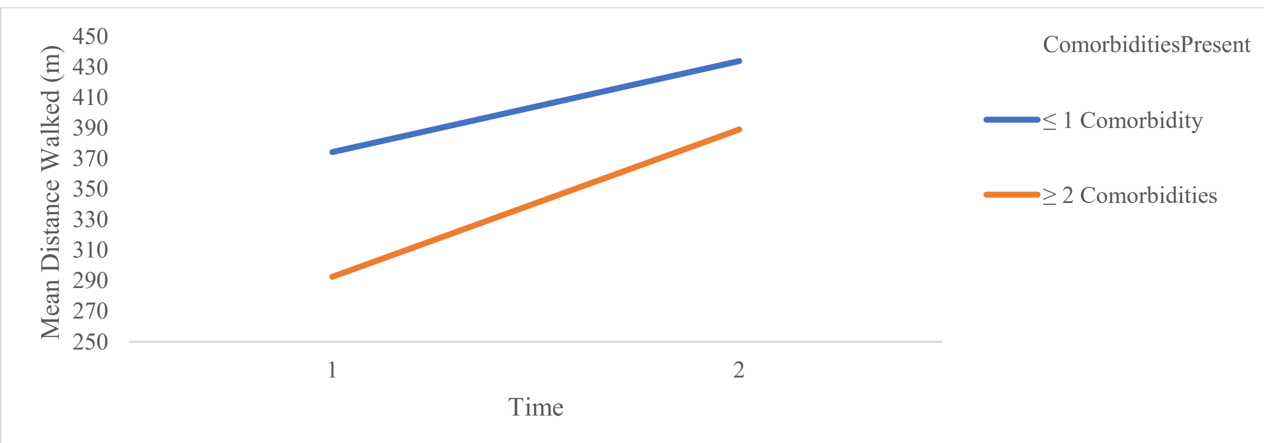
Note. This figure displays the estimated marginal means of measure for the SCPT (W) pre- and 6-months post-surgery.

c. Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

There was no statistically significant interaction effect between comorbidities present and time on the SMWT (m) as displayed in Figure 12 (see Appendix J), $F(1,26)=1.06$, $p>.05$, $\eta^2=.03$. There was a statistically significant main effect for comorbidities present with a large effect size on the SMWT (m) with an increase in distance walked (m) for participants presenting with ≤ 1 and ≥ 2 comorbidities as displayed in Figure 12 (see Appendix J), $F(1,26)=5.30$, $p<.05$, $\eta^2=.16$. There was a statistically significant main effect for time with a large effect size on the SMWT (m) with an increase in distance walked (m) for participants presenting with ≤ 1 and ≥ 2 comorbidities as displayed in Figure 12 (see Appendix J), $F(1,26)=19.13$, $p<.05$, $\eta^2=.42$.

Figure 12.

Estimated Marginal Means of Measure (Pre- Versus Post-Surgery) for The SMWT (m)



Note. This figure displays the estimated marginal means of measure for the SMWT (m) pre- and 6-months post-surgery.

Question #4: Is there a relationship between BMI scores and pre-versus post-surgical functional performance measures, respectively?

A Pearson Correlation coefficient was calculated at $\alpha=.05$ (two-tailed) in order to analyze the linear relationship between BMI scores and functional test measures scores for the SCT, SCPT, and SMWT. There was a statistically significant linear positive correlation for BMI and the SCPT (W) scores post-operatively with an increase in power output (W) in relation to increasing BMI scores, $r(26)=.34$, $p<.05$, n=28, CI:[.027, .67] as displayed in Table 5.

Additionally, there was a significant negative correlation for BMI and the SMWT (m) scores post-operatively with a decrease in distance walked (m) in relation to increasing BMI scores $r(26)=.-42$, $p<.05$ n=28 CI:[-.687, -.057] as displayed in Table 5. Inferential statistics did not reveal any other significant correlations for BMI scores and functional test measures scores. scores.

Table 5.

Correlations Between BMI Scores Across Functional Test Measures

		Body Mass Index	Stair Climb Test Pre-Surgery (s)	Stair Climb Power Test Pre-Surgery (s)	Stair Climb Power Test Pre-Surgery (W)	Six Minute Walk Test Pre-Surgery (m)	Stair Climb Test Post-Surgery (s)	Stair Climb Power Test Post-Surgery (s)	Stair Climb Power Test Post-Surgery (W)	Six Minute Walk Test Post-Surgery (m)
Body Mass Index (kg/m^2)	Pearson Correlation	1	.06	.23	.36	-.27	.34	.34	.39*	-.42*
	Sig. (2-tailed)		.73	.23	.05	.15	.07	.06	.03	.02
	N	28	28	28	28	28	28	28	28	28

Note. This table displays the correlations between BMI scores across functional test measures.

Chapter 4: Discussion

Question #1: Is there an effect of smoking status on pre- versus post-surgical functional performance measures, respectively?

Firstly, addressing the interaction effect between smoking status and time, it was determined that there were no statistically significant differences between smoking status and time across any functional tests [SCT (s), SCPT (s) SCPT (W), and SMWT]. This indicates that the effect of one independent variable (smokers/former smokers versus non-smokers) on the dependent variable (test score outcomes) was not reliant on the level of the other independent variable (pre- and post-test). This shows no differences between smokers and non-smokers' time taken to ascend/descend stairs, average power produced ascending stairs, or distance walked across testing sessions (pre- and post-operatively). Since no statistically significant differences were reported no conclusive statements can be made about performance. However, results revealed that smokers ascended and descended stairs slower than non-smokers while also producing more power compared to non-smokers on average. Smokers also did not walk as far compared to non-smokers in the present study. Secondly, addressing the first main effect of smoking status, it was determined that there were no statistically significant differences for smoking status on any functional test measures. This indicates that there were no significant differences between the mean scores of smokers/former smokers compared to non-smokers on functional tests. Finally, addressing the second main effect of time, it was determined that there were statistically significant differences for time on all functional tests. This indicates that there were significant differences between mean scores on testing measures when comparing pre- versus post-surgery test scores. Additionally, the difference in mean change between scores pre- and post-operatively was greater in the smoking group as compared to the non-smoking group indicating that non-smokers may have a greater margin of improvement on functional testing. The smoking group (smokers/former smokers and non-smokers) mean scores improved on all testing measures. On average, smokers ascended and descended stairs slower while also walking a shorter distance both pre- and post-operatively compared to non-smokers indicating that non-smokers performed better on functional testing. Pertaining to the SCPT (W), smokers produced more power ascending stairs than non-smokers both pre- and post-operatively. It is important to note that when comparing testing sessions (pre- versus post-operatively) it was shown that regardless of participant classification (smokers/former smokers versus non-smokers), both groups had a decreased time to ascend and descend stairs, an increased power output ascending stairs, and a farther overall distance walked. This was indicative that both groups had a positive improvement of scores across all testing measures post-operatively as expected following TKA with non-smokers having a larger margin of improvement than non-smokers. Non-smokers did climb stairs faster and walk further distance compared to smokers, however, smokers had a greater margin of improvement pre- versus post-operatively for the SCT (34.5%), SCPT (s; 29.1%), and SMWT (35.3%). On the other hand, non-smokers had an improvement of 30.8%, 22.7%, and 14.6% on the SCT, SCPT (s) and SMWT, respectively. Research by Bade and colleagues (2010) found similar findings for the SCT and additional physical performance measures, specifically for the SCT where participants had an improvement 22% at 6-months following TKA. Findings are similar to the present study which found a 34.5% and 30.8% improvement for smokers and non-smokers respectively. Looking at the SCPT (W), smokers also had a greater marginal improvement (26.1%) compared to non-smokers (22.6%).

Research conducted by Arafa and colleagues (2024) found that after adjustment for age, sex, lifestyle, and medical conditions, stair climbing was inversely associated with obesity and smoking status. Although Arafa and colleagues (2024) did not include the involvement of patients receiving surgery, it does support the notion of how smoking negatively affected the SCT (s). When comparing these findings to the present study, similar notions can be made that smokers may perform worse on functional testing compared to non-smokers. This was based on smokers taking a longer time to complete the functional tasks compared to non-smokers. Smoking causes vasoconstriction, which limits blood flow and oxygenation to muscles, resulting in early fatigue (Bedard et al., 2018). Smokers also tend to experience slower recovery times from surgeries, such as TKA, due to impaired wound healing, further hindering rehabilitation and performance on functional tests (Archunan et al., 2021). These negative effects of smoking may provide some relevance as to why smokers may perform worse on functional testing as poor oxygenation and muscle function may impair daily movement and function. Although various factors were not accounted for in the smoking group, such as if participants also had a high BMI and/or consumed alcohol, the testing scores indicated that the non-smoker group may have performed better. This can be supported based on higher overall mean time (s) and distance (m) in testing measures and a higher mean improvement post-operatively compared to smokers. Research conducted by Melliti and colleagues (2021) further investigated the effects of smoking on the SMWT (m) and found that smokers had reduced exercise capacity during this test with decreased walked distance (m) and inspiratory capacity. During cardiopulmonary exercise testing, their research found that smokers had higher minute ventilation for a given submaximal intensity and lower minute ventilation at maximal exercise (Melliti et al., 2021). Their research supports the notion that smoking alters lung function during submaximal and maximal exercise. In the present study, similarities can be noted when compared to Melliti and colleagues (2021) as smokers walked a lower mean distance on the SMWT (m) compared to non-smokers.

Ventilation is directly related to energy demands during exercise, as ventilation increases, so does metabolic rate during mild to moderate physical activity however smoking inhibits oxygenation of organs and tissues thus impairing the body during physical activity (Pasupathi et al., 2009). This may indicate that non-smokers performed better on the SMWT, however, in contrast to previous research, the current study did not find statistically significant differences regarding if smoking decreases walking distance. Smokers did walk less distance than non-smokers similar to findings from Fritschi and colleagues (2013) who found that smokers walked shorter treadmill distances than non-smokers (375.5±238.4 versus 415.2 ± 229.6 meters), but the differences were not statistically significant. Smokers in the present study also had a higher average power output on the SCPT (W). Once again ambiguity is present with these findings as higher power output (W) in previous research may indicate better performance, however, previous research also reports that smoking accounts for worse performance on test measures (Arafa et al., 2024). The present study was not able to determine if other factors in conjunction with smoking may have led to increased power (W) such as having a higher BMI. A higher body mass may lead to a higher average power (W) when producing movement due to the need to overcome a higher inertia. BMI is calculated by weight (kg) and dividing by height (m^2), additionally, average power is calculated by multiplying weight (kg) by gravity ($9.8m^2$) multiplying by distance (m) and dividing by time (s). This allows for the ability to compare mean power across both individual participants and a group. Regardless of additional factors, smokers did have a higher mean power output compared to non-smokers both pre- and post-operatively. This may be due to the effects of smoking not directly influencing power output (W) but rather a catalyst to other factors that lead to negative power output such as increased BMI. Smoking has been shown to negatively impact outcomes after TKA demonstrated by significant impacts on functional test measures, such as the SCT, SCPT, and the SMWT, in several ways (Pourmoghaddam et al., 2016). Firstly, it adversely affects cardiovascular fitness by damaging blood vessels and reducing oxygen delivery to tissues, leading to decreased stamina and endurance during physical tasks (Bonnefoy-Mazure et al., 2017; Brock et al., 2017). Moreover, long-term smoking is associated with muscle weakness and atrophy, particularly in the lower limb muscles essential for activities like climbing stairs or walking. Respiratory issues linked to smoking, such as chronic obstructive pulmonary disease, can cause breathlessness during physical activities, affecting the ability to sustain effort in tests like the SMWT (Bedard et al., 2018). Overall, these combined effects contribute to poorer performance in functional tests, with smokers typically exhibiting decreased power output and longer completion times compared to non-smokers.

Additionally, previous activity level, post-operative rehabilitation protocol, and/or compensatory movement were not monitored during testing of the present study which may or may not have affected results. Although results show that non-smokers may have performed better on all testing measures except the SCPT (W) both pre- and post-operatively it is not possible in the present study to confirm if in fact this is due to simply not smoking or a plethora of other factors such as but not limited to impaired recovery. In conclusion, based on the results of the present study alone, participants who do smoke may perform worse on functional testing both pre- and post-operatively excluding the SCPT (W).

Question #2: Is there an effect of alcohol consumption status on pre- versus post-surgical functional performance measures, respectively?

Addressing the interaction effect between alcohol consumption status and time, it was determined that there were no statistically significant differences between alcohol consumption status and time across any functional tests [SCT (s), SCPT (s) SCPT (W), and SMWT (m)]. This indicates that the effect of one independent variable on the dependent variable is not reliant on the level of the other independent variable, in this case being alcohol consumption status (drinkers versus non-drinkers) and time (pre- versus post-surgery) on functional tests. This shows that there were no differences between the drinking group across testing sessions both pre- and post-operatively on the above listed functional tests. Secondly, addressing the first main effect of alcohol consumption status, it was determined that there were no statistically significant differences for alcohol consumption status on any functional test measures. This indicates that there were no significant differences between the mean scores of drinkers compared to non-drinkers on functional tests. Finally addressing the second main effect of time, it was determined that there were statistically significant differences for time on all functional tests. Between testing sessions, the drinking group (drinkers and non-drinkers) mean scores improved on all testing measures for the SCT (s), SCPT (s), SCPT (W), and SMWT (m). On average drinkers took a longer time to ascend and descend stairs while having a lower average power (W) and distance walked on the SMWT (m). Interestingly, drinkers walked a farther distance pre-operatively than non-drinkers, but then walked a shorter distance post-operatively, compared to non-drinkers. This indicates that non-drinkers performed better on these three functional tests except the SMWT (m) pre-operatively based on the decreased time (s) to ascend and descend stairs and increased distance walked. When comparing pre- versus post-surgery test scores, participants improved on testing post-operatively regardless of if they drank or not. Non-drinkers performed better on these tests with the exception of the SMWT (m) pre-operatively, non-drinkers had a greater margin of improvement post-operatively on the SCT (s) and SMWT (m), with the opposite being found for the SCPT (s). Non-drinkers improved by 35.9%, 22.6%, 21.1%, and 29.8% on the SCT (s), SCPT (s), SCPT (W), and SMWT (m), respectively. While comparing the drinkers' improvement, a 31%, 26.4%, 25.7% and 18.5% improvement was found for the SCT (s), SCPT (s), SCPT (W), and SMWT (m), respectively.

Research conducted by Vancampfort and colleagues (2020) found that patients who consumed alcohol walked a significantly shorter distance on the SMWT (m) as compared to those with no alcohol use (649.0 ± 72.9 m versus 724.4 ± 89.0 m). This notion was also supported by the present study which showed that drinkers not only walked less distance post-operatively, but also recorded a lower average power on the SCPT (W). Additionally, King and colleagues (2022) conducted a study including 278 participants with a mean age of 67 years. Pre-TKA 6MWT (m) distance was reported to be 323.1 (m) and mean 12-month 6MWT (m) distance was 396.0 (m). This indicates a marginal improvement of 23.3%. Although this study compared 6-month, and 12-month testing compared to pre- and 6-months post-surgery. It is expected that improvement begins to taper off at the 1-year follow-up point (King et al., 2022). It is unclear why participants who consumed alcohol in the present study walked farther on the SMWT (m) pre-operatively only. This may or may not be due to the limited sample size of participants within the study itself, decreasing generalizability or potentially having participants in the drinking group actually being healthier overall and having better cardiovascular fitness. The present study may have had minimal differentiation between the drinking and non-drinking groups. For example, participants who were classified as drinkers or non-drinkers may have had other underlying conditions that interacted with other risk factors and may have hindered or did not affect there overall functional testing scores. However, regardless of testing scores it has been shown that drinking alcohol may adversely affect functional test measures (Rotevatn et al., 2017). Limited research has been conducted on the effects of TKA on functional test measures (Gold et al., 2020). Research conducted by Lavernia and colleagues (2013) found that moderate drinkers had better pre-operative scoring on patient reported outcome measures such as pain and activity level, and shorter length of stay in hospital than non-drinkers. However, after surgery, self-reported abstainers achieved greater improvements in general health score which was recorded using survey-based questions. Non-drinkers who have multiple comorbidities would be expected to perform worse than their counterpart who only consumed one drink per week (Lavernia et al., 2017). Similarly, a participant who consumes one drink or 10 drinks per week was classified in the same group in the current study, showing how minimal differentiation between participants could possibly have impacted testing and the analysis of the results supporting the use of stratification based on number of drinks consumed.

Research does support the notion that alcohol consumption may negatively impact muscle function and recovery by altering protein synthesis and reducing overall physical conditioning (Rotevatn et al., 2017). These combined effects can result in poorer outcomes in performance with functional testing, with individuals who consume alcohol typically demonstrating reduced power output, longer completion times, and an increased likelihood of falls or injuries. Conflicting information is indeed present within this study as results indicate that participants who consumed alcohol performed better on the SMWT (m) pre-operatively, however, once the surgical intervention occurred, the non-drinkers performed better on all functional testing measures. Rotevatn et al. (2017) highlighted that a knowledge gap existed regarding post-operative outcomes for low to moderate alcohol consumers, warning against potential misinterpretations of morbidity and mortality rates. A comprehensive categorization such as 1 drink, 2-4 drinks, 5-10 drinks, or more than 10 drinks consumed allows for a more detailed stratification of drinks consumed and breakdown in terms of the analysis.

Question #3: Is there an effect of comorbidities present on pre- versus post-surgical functional performance measures, respectively?

When addressing the interaction effect between comorbidities present and time, it was found that there were no statistically significant differences for comorbidities present and time across any functional tests [SCT (s), SCPT (s) SCPT (W), and SMWT (m)]. As displayed in Figures in 9-11, although an interaction effect seems to be visually present, a lack of statistical significance may be indicative of insufficient power due to sample size. Secondly, addressing the first main effect of comorbidities present, it was determined that there were statistically significant differences for comorbidities present on the SMWT (m) only but no other statistically significant differences for any other functional tests. This indicates that there were differences within the testing groups ($\leq$ 1 comorbidity versus $\geq$ 2 comorbidities) in regard to distance walked on the SMWT (m) with the $\leq$ 1 comorbidity group walking a farther distance (m) both pre- and post-operatively. Finally addressing the second main effect of time, it was determined that there were statistically significant differences for time on all functional tests. This indicates that there were significant differences between mean scores on testing measures when comparing pre- versus post-surgery test scores. On average participants presenting with $\geq$ 2 comorbidities had a higher mean score on the SCT (s). Participants presenting with $\geq$ 2 comorbidities ascended/descended stairs slower pre-operatively but faster post-operatively as compared to participants with $\leq$ 1 comorbidity. For the SCPT (W) and SMWT (m), participants with $\geq$ 2 comorbidities produced less power ascending stairs and also walked a shorter distance compared to those with ≤ 1 comorbidity both pre- and post-operatively. It is important to note that comparing testing sessions across time showed that regardless of participant classification (≤ 1 comorbidity versus ≥ 2 comorbidities) both groups demonstrated a faster time to completion when ascending and descending stairs and an increased average power produced when ascending stairs. Both groups also had and increased power output ascending stairs and demonstrated farther walking distance post-operatively. This demonstrates that both groups may have had a positive improvement of mean scores across all testing measures post-operatively as expected following the TKA.

Gregg and colleagues (2000) found that 32% of women and 15% of men ≥60 years of age with diabetes an additional comorbidity reported an inability to walk one-quarter of a mile (400 m) and climb stairs compared with women and men without comorbidities. Additionally, diabetes and other comorbid conditions were found to be associated with up to threefold increased odds of not being able to do each task among both men and women (Gregg et al., 2000). This study also found that among women, diabetes was associated with slower walking speed (Gregg et al., 2000). Comorbid conditions such as arthritis, osteoporosis, and/or cardiovascular disease can lead to joint pain and stiffness, limiting mobility and resulting in slower completion times and decreased power output of functional testing (Abdelmegied et al., 2020). Previous research both supports and contrasts what the present study found. It would be expected that participants who presented with more comorbidities than others would perform worse on functional testing, however, this is not what the present study found. Participants in the ≥ 2 comorbidities group actually had a greater margin of improvement in regard to mean time (s) on the SCT (s), SCPT (s) and distance walked (m) on SMWT (m) post-operatively. Previous research not only explained that participants with multiple comorbidities performed worse on functional testing, but also had a smaller margin or improvement following intervention compared to their counterpart who had no comorbidities. This was supported by Kelly and colleagues (2016) who found that low velocity group weighed more and had more comorbid conditions resulting in worse performance on the SMWT.

Participants with ≤ 1 comorbidity performed better post-operatively on all testing measures compared to those with ≥ 2 comorbidities with the exception of the SCPT (s) post-operatively as shown in Table 4. Research not only explained that participants with multiple comorbidities performed worse on functional testing, but also had a smaller margin or improvement following intervention compared to their counterpart who had no comorbidities (Masaracchio et al., 2017). This was supported by Kelly and colleagues (2016) who found that low velocity group weighed more and had more comorbid conditions resulting in worse performance on the SMWT. The only contradictory findings in this study to what previous research has found with similar cohorts with comorbidities was that the ≥ 2 comorbidities group had a greater margin of improvement in time (s) power (W) and distance (m) walked as compared to the ≤ 1 comorbidity group. Although no interaction effect was present, and the marginal improvement was greater between the ≥ 2 versus the ≤ 1 comorbidity group, participants categorized in the ≤ 1 comorbidity group completed stair climbing tests faster and walked further. Thus the ≤ 1 comorbidity group, who improved the least, still had an overall better performance regardless of differences in improvement. Looking at the specific differences in improvement, participants with ≥ 2 comorbidities improved by 38.4%, 30.9%, 33.5%, and 33% post-operatively on the SCT (s), SCPT (s), SCPT (W), and SMWT (m), respectively. While the ≤ 1 comorbidity group improved by 27.6%, 21.4%, 18.8%, and 15.9% on the SCT (s), SCPT (s), SCPT (W), and SMWT (m), respectively. Although not including a 6-month follow-up testing session but a 12-month instead, King and colleagues (2021) found similar findings as the present study. For participants with ≤ 1 comorbidity a marginal improvement of 25.7% was found compared to those with ≥ 2 comorbidities who had a marginal improvement of 22.3% 12-moths post-operatively. This study included only 12-month follow up testing. Previous research supports the marginal improvements post-operatively begin to slow after the 6-month period indicating marginal improvement may have been similar to the present study at 6-months. Comparing the current study with Kelly and colleagues (2016), comorbidities of the less active group correlated with a slower stair climb time at baseline. At post-testing both groups exhibited significantly improved scores for all outcome measurements with higher scores being present in the more active group, coincidentally who also weighed less and presented with less comorbid conditions (Kelly et al., 2016). The present study did not include a high versus low velocity group, however, post-operative scoring was similar comparing the two studies indicating improvement may have occurring on the SMWT (m) based on the increased mean distance walked (m) after TKA intervention. In contrast post-operative testing of the present study found that participants may have had a smaller margin of improvement for ≤ 1 comorbidity group compared to the ≥ 2 comorbidities group. This contradicts the findings of Kelly and colleagues (2016).

Although the margin improvement post-operatively for the ≤ 1 comorbidity group is lower than expected, it can be hypothesized that this group may have used compensatory movements giving an inaccurate representation of their true ability pre-operatively. Breathing difficulties, increasing breathlessness, and fatigue during exertion, negatively impacts performance in sustained activities like the SMWT resulting in poorer performance as compared to participants without these factors. Medications taken for comorbid conditions can also result in side effects like drowsiness or dizziness, further impacting physical performance (Masaracchio et al., 2017). These factors may have further impacted functional performances in either group resulting in the variable findings. Additionally, conditions such as but not limited to obesity, diabetes, and cardiovascular diseases can complicate surgical procedures, leading to increased operative times, higher rates of infection, and prolonged hospital stays (Podmore et al., 2018). These factors not only influence the immediate surgical experience but can also impede long-term recovery, ultimately diminishing patients' functional mobility and overall satisfaction with the procedure and may lead to poor post-operative functional testing.

In conclusion, the relationship between comorbid conditions and functional test outcomes remains complex and multifaceted. While certain comorbidities, such as obesity or cardiovascular issues, often correlate with decreased performance on functional tests, the extent to which they interact and/or directly influence post-operative outcomes can vary significantly among individuals. Factors such as age, overall health status, and adherence to rehabilitation protocols may also play critical roles in determining functional recovery. Thus, while there is a tendency for comorbid conditions to present challenges that could lead to negative outcomes during or after surgery and on performance measures using functional assessments, the impact may not be universally applicable (Roth et al., 2019). Further research is necessary to elucidate these dynamics and interactions and to develop tailored interventions that address the unique needs of patients with varying comorbid profiles.

Question #4: Is there a relationship between BMI scores and pre-versus post-surgical functional performance measures, respectively?

There was a statistically significant negative correlation between BMI and the SMWT (m) scores post-operatively. Inferential statistics did not reveal any other significant correlations for BMI scores and functional test measure scores. This relationship suggests that as BMI increased, the average distance covered during the SMWT (m) decreased. This indicates that individuals with higher BMI may experience reduced walking distance as compared to those with a lower BMI (Mizneret al., 2011). This was potentially due to factors such as increased energy demands, cardiovascular limitations such as poor blood circulation resulting in limited oxygenation of muscles, and/or potential musculoskeletal challenges such as limited strength/ROM restricting movement (Bonnefoy-Mazure et al., 2017). These statistically significant findings support that BMI may correlate with decreased performance. There was a statistically significant linear positive correlation between BMI and the SCPT (W) scores post-operatively. A linear positive correlation between BMI and the SCPT (W) showed that as BMI increases, the average power output produced each second during the SCPT (W) increased (Strotmeyer et al., 2022; Roth et al., 2019). This relationship suggests that individuals with higher BMI produced greater power output during stair climbing. However, this contrasts with findings from other functional tests [SCT (s), SCPT (s), SMWT (m)], where higher BMI often correlates with decreased performance (Abdelmegied et al., 2020). This may be due to challenges such as, but not limited to, poor circulation resulting in limited oxygenation of tissues along with weight (kg) being included in the calculation thus the higher the weight, the more power (W) produced (Pourmoghaddam et al., 2016). No relationships between BMI and all other functional tests were found. Negative relationships between BMI and the SCT (s) and SCPT (s) were also noted which may suggest similar notions as the relationship between BMI and the SMWT (m). Thus, as BMI increases mean tests scores on the functional tests will worsen, or in this case, an increase in time taken to ascend and descend stairs and a decrease in distance walked. However, no statistical significance was noted between BMI and the SCT (s) and SCPT (s) as compared to the SCPT (W) and SMWT (m).

Overall, this significant positive correlation highlights the complexity of using functional performance measures for assessment in post-operative patients. It underscores the need for tailored rehabilitation strategies that consider the interplay between BMI and functional capacity along with other recovery measures such as pain, ROM, or strength, particularly for activities that require strength and power, like stair climbing. This statistically significant difference can help optimize recovery outcomes for patients following TKA.

Research conducted by Strotmeyer and colleagues (2022) with a sample size of 455 hypothesized that physical function was directly related to the SCT (s) and SCPT (W). Their findings suggested that individuals with lower physical activity, higher BMI, and greater comorbidity rates resulted in significantly poorer performance on the SCT (s) and SCPT (W). Specifically, it was determined that these participants exhibited lower peak power (121.9 ± 34.5 W versus 161.4 ± 39.0 W) and average power (94.9 ± 24.3 W versus 124.1 ± 28.4 W) when comparing healthy versus obese participants (Strotmeyer et al., 2022). As compared to the present study, Strotmeyer and colleagues (2022) suggested that a higher BMI may lead to increased power output on the SCPT (W) due to the higher overall body mass (kg) of participants contradicting previous research. Strotmeyer and colleagues (2022) adjusted for factors such as age, sex, and comorbidities present as compared to the present study which did not adjust for confounding variables. These findings may infer that differences in power (W) may be due to other factors. Factors such as an older age and higher BMI remained a significant predictor of slower stair climb times and reduced power outputs (Strotmeyer et al., 2022). Participants who presented with a lower BMI produced less power on average on the SCPT (W) which is inversely related to previous research as suggested by Strotmeyer et al. (2022). The differences in the present study may may be a result of various factors. Firstly, although it is suggested that participants with a higher BMI perform worse on the SCPT (W) there is ambiguity surrounding this notion. Power output (W) is based on body mass, and time to completion, so it is expected that a higher body mass requires more power (W) to initiate movement. Conversely, a higher body mass may result in a slower completion time resulting in a lower average power output (W) across time. Comparing this notion to participants with a lower BMI, it may take less power (W) to initiate the movement, however, an overall faster completion time resulting in higher average power output (W). The present study did not account for factors such as these and instead only looked at the relationship of absolute BMI scores and functional testing in order to determine of any relationships existed. Absolute BMI scores and testing outcomes was compared to eliminate grouping of participants. Ronai and colleagues (2020) reported that the time taken to ascend the stairs in the SCPT correlates with overall lower extremity power, making it a reliable measure of power production. The SCPT engages muscles surrounding the knee, effectively capturing the limitations imposed by OA and the effects of TKA on outcomes (Holm et al., 2020). Participants in the present study were allowed to use assistive devices during testing, and factors such as using a railing, or compensatory movements aside form BMI may have affected power output on the SCPT (W). The understanding of higher BMI scores and the associated risk factors may imply that increased BMI negatively impairs SCPT (W) scores (Bonnefoy-Mazure et al., 2017). This may be a result of the increased body mass associated with a higher BMI or the known factors that negatively affect health of people with high a BMI such as impaired breathing and movement

Another study by Lange-Maia and colleagues (2019) compared levels of physical activity versus stair climb performance. This study found that average baseline stair climb time was 18.12 (s). Smoking, diabetes, the presence of OA, fair/poor health, and stroke were associated with a slower pace and higher time to complete the functional performance test (Lange-Maia et al., 2019). In separate results, a higher BMI, the presence of OA, fair/poor health, and diabetes were each associated with longer time taken to ascend/descend stairs each year indicating worsening scores as described by Lange-Maia and colleagues (2019). Comparing these findings with the outcomes of the present study, it can be observed that when looking at BMI correlation, other factors such as smoking, alcohol consumption, and comorbidities present were not excluded from the analysis. Thus, there is no understanding of the impact of how other lifestyle risk factors and/comorbidities may have affected BMI correlation towards the SCPT (W). However, it is essential to interpret this correlation carefully, as a statistical relationship does not imply causation. Factors such as muscle mass, fitness level, or technique in the SCPT (W) could have also influenced power output as supported by Allen et al. (2022). Research conducted by Abdelmegied et al. (2020) identified that post-operative scores for obese patients were worse compared to non-obese patients based on a longer time taken to ascend and descend stairs and a shorter distance walked. Their meta-analysis further revealed that complications such as infections and deep vein thrombosis occurred more frequently in obese patients. Similarly, Bonnefoy-Mazure et al. (2017) found that, at baseline, gait velocity, and knee ROM were significantly lower in obese patients compared to non-obese patients. This supports the rationale that obese patients may perform worse on functional testing due to factors such as impaired heath and musculoskeletal strain. Impaired health may be explained by factors such as cardiovascular strain where blood circulation may be worse in obese patients limiting oxygenation to muscles and surrounding tissues (Abdelmegied et al., 2020). Additionally, musculoskeletal strain may be explained by the additional weight of the patient limiting their ROM in conjunction with a low muscle mass to weight ratio creating a greater difficulty to move/ambulate. Although the previous studies by Lange-Maia and colleagues (2019) and Strotmeyer and colleagues (2022) did not specifically conclude that BMI was associated with worse scores on the SCPT, it did support the notion that obese patients tended to experience more complications than their non-obese counterparts (Abdelmegied et al., 2020). Subsequently, due to the nature of the testing protocol and follow-up following TKA, it is unclear if post-operative impairment, lack or representation from sample size, or underlying factors not accounted for such as lifestyle risk factors affected the bivariate correlation. Overall, these factors collectively compare the observed correlation between BMI and SCPT scores post-operatively, emphasizing the complexity of functional performance regarding body weight. Based on the present study, correlational analysis may suggest that a higher BMI leads to an increased power output (W) on the SCPT (W). Other relationships were also noted for the BMI in relation to the SCT (s) and the SCPT (s) however these relationships are without significance. These relationships, as noted early, were similar in nature to the negative relationship between BMI and the SMWT (m) scores. These results, without significance may indicate that as BMI increased, an increased time would be reported on the SCT (s) and SCPT (s) which would refer to a poorer performance. Understanding these relationships is essential for designing effective rehabilitation programs that cater to the unique needs of individuals with varying BMI after surgery.

Incorporating walking tests, such as gait analysis and the SMWT, is vital for assessing limitations in physical ability and tracking the progression of both pre- and post-TKA (Hatfield et al., 2011). Emphasizing muscle strength and ROM is crucial in the treatment of TKA patients during both phases of their recovery. Evaluating a patient's ambulation capabilities can provide valuable insights into their strengths and limitations, aiding in the development of effective rehabilitation strategies. The statistically significant negative correlation found between BMI and SMWT scores post-operatively may be explained through various physiological and biomechanical mechanisms that affect functional capacity and endurance (Bonnefoy-Mazure et al., 2017). A higher BMI leads to increased energy expenditure during physical activities. Research conducted by Mendelson and colleagues (2014) compared 20 healthy weight and 20 obese participants that found lower distance achieved during the SMWT and exertional breathlessness was greater when comparing healthy versus obese participants. Obese adolescents breathed at lower lung volumes, lower-end expiratory, and end-inspiratory lung volumes during exercise resulting in decreased oxygenation and poor functional test scores such as distance walked. Moreover, a higher BMI may correlate with lower muscle strength relative to body weight, especially if the weight gain is primarily due to fat rather than muscle. Now comparing the findings of the present study to previous research, inferences can be made that a higher BMI may lead to worse SMWT (m) scores. Although ambulatory assistance was provided if needed, as compared to the SCPT (W) there is limited ways compensatory movement may affect testing scores. Walking aids were used by some participants, however, due to the longer testing time, these aids may not have provided any benefit in terms of total distance walked. Similarly, the SMWT (m) incorporates a level of endurance during the test and participants with more comorbidities, smokers, and drinkers may have been affected more intensely on this test.

This can further impair overall functional capacity and endurance. Given the ability to assess endurance levels and the possibility of increasing knee pain, the SMWT is widely utilized for patients with impaired cardiovascular systems or progressive knee OA. Previous research suggests that functional test scores from the SMWT may be valuable in predicting the success of TKA for patients with end-stage knee OA (Bennell et al., 2011). Lin and colleagues conducted a study in trained versus untrained patients after receiving a TKA. At six months post-operatively, they found that SMWT (m; 413.88 ± 44.61 after intervention) were significantly higher than those of their healthy group. Although speculative, limited oxygen delivery to working muscles during exertion may have resulted in an earlier onset of fatigue during the SMWT, as the cardiovascular system struggles to meet the metabolic demands of increased body mass. Respiratory function may also be negatively impacted by obesity, with conditions such as obesity hypoventilation syndrome which is a breathing disorder that affects some people who have obesity. The condition results in too much carbon dioxide in your blood and not enough oxygen. Additionally, patients who are obese often present with sleep apnea which may reduce lung capacity. These factors may have played a role in the significantly negative correlation with BMI and the SMWT (m). As a result, individuals with higher BMI may experience breathlessness during sustained efforts, making it challenging to maintain their pace throughout the walk.

Collectively, these factors may have contributed to decreased walking endurance and capacity in individuals with higher BMI, highlighting the importance of targeted rehabilitation strategies that address the unique challenges this population faces following surgery. Understanding these relationships is crucial for improving post-operative outcomes and enhancing functional mobility in TKA patients. Overall, based on the present study, it was noted that as BMI scores increased, SMWT (m) scores for post-operative TKA patients decreased showing a negative relationship.

Limitations

This study has several notable limitations that warrant careful consideration. The statistical power of the two-way mixed factorial ANOVA was limited due to the small sample size. This could result in an inability to detect meaningful differences between groups, particularly if the subgroups, such as smokers versus non-smokers or individuals with varying comorbidity levels, resulting in the inability to reflect the target population. These groups are potentially inadequately represented with a sample size of 28 participants, which poses a significant challenge to the generalizability of the findings. A total of 44 patients were tested pre-operatively with a total of 16 being lost between surgery and the 6-month follow-up phase of the study. The results may not accurately reflect the broader population undergoing TKA, particularly given the diverse range of factors influencing surgical outcomes across different demographic and clinical background thus being another limitation. Uncontrollable factors such as the inability to contact participants and declined follow-up visits resulted in the loss of participants in the study. Factors such as this can be prevented in the future by providing a wider range of scheduled follow-up sessions, an increased amount of check-in periods via email or telephone, and reiteration of testing protocol to increase the awareness of participants and the underlying study.

Finally, the selected performance-based tasks, including the SCT, SCPT, and SMWT, may not fully capture the complexity of functional mobility. While these tests are valuable, they focus primarily on specific aspects of physical performance and may overlook other important dimensions of daily function or other variables that may be used in isolation or together with functional performance measures (e.g., pain, ROM, and/or strength). Additionally, variability in how participants executed these tasks or adhered to pre-operative instructions could introduce bias into the results. In summary, while the study offers important insights into predictors of functional outcomes following TKA, limitations must be acknowledged to provide a balanced and accurate interpretation of the findings. Addressing these limitations in future research may enhance the understanding of how to these variables may impact on functional performance and success post-operatively.

Future Direction and Recommendations

Studies with a higher recruitment and/or comparing differences in function between the 6-month and 12-month follow-up periods may effectively capture varying differences in marginal improvement not captured at the 6-month follow-up period (Fransen et al., 2017). Employing a diverse range of outcome measures, including knee ROM, strength, and subjective pain or fear avoidance before/after as other dependent measures may add a greater detail of comparison between testing measures. Future research should also account for additional confounding variables, such as adherence to rehabilitation protocols and the myriad of interactions possible. Monitoring physiotherapy sessions during the first 6-8 weeks post-surgery or long-term (0-12 months) may provide a more detailed understanding of testing results. Considering pre-operative activity levels and psychological factors may enhance the predictive ability of using functional performance measures and outcomes (Gold et al., 2020). Evaluating the effectiveness of pre-operative interventions, such as smoking cessation, nutritional counseling, or prehab in physical therapy, may reveal how these factors affect recovery (Bellemans et al., 2005; Cui et al., 2020). Finally, using wearable technology to track physical activity and mobility in real-time may yield objective data on functional performance and adherence to rehabilitation protocols post-surgery (Christensen et al., 2023) that may also affect functional performance. Collaborating with fields like psychology, nutrition, and rehabilitation sciences may enhance the research framework and foster a better understanding of the factors influencing recovery and functionality (Binkley et al., 1999; Masaracchio et al., 2017).

Chapter 5: Conclusion

The primary aim of this study was to examine the influence of lifestyle risk factors and comorbidities on functional performance in TKA patients before and after surgery. Increasing attention has been given to how these factors affect TKA outcomes. Smoking, alcohol consumption, and a higher BMI are known to negatively impact recovery and surgical results. Understanding the effects of lifestyle risk factors and comorbidities on TKA patients is crucial, especially as the number of TKA patients continues to rise. The present study did not find statistically significant differences across all functional performance testing measures between smoking, alcohol consumption, or comorbidities groups when comparing pre- versus post-operative functional test results. All functional performance measures improved post-operatively which included ascending and descending stairs faster, producing more power when ascending stairs, and ultimately being able to walk farther distances. Although performance improved across all testing measures post-operatively, notable changes were present. Regarding marginal improvement, smokers had a greater percent change than non-smokers, which was also found for participants with ≥ 2 comorbidities versus ≤ 1 comorbidity for all tests. Regarding alcohol consumption status, non-drinkers recorded a higher marginal improvement than drinkers for the SCT (s; 35.9% versus 31%) and the SMWT (m; 29.8% versus 18.5%). While the opposite was found for the SCPT (s) and SCPT (W) where drinkers had a higher marginal improvement (26.4% versus 22.6% and 25.7% and 21.1%). Regardless of marginal improvement, non-drinkers recorded the highest mean power on the SCPT (W; pre- and post-operatively) and distance on the SMWT (m; post-operatively) compared to drinkers. Although conclusive statements can not be made regarding statistical significance this study has been able to identify various differences in performance pre- versus post operatively based on mean scores and marginal changes potentially affected by lifestyle risk factors and comorbid conditions. Future research should continue to expand on performance-based measures with a focus on increased recruitment and comparison of performance-based measures at 12-months post-operatively.

References

Abdelmegied, W. S., Sallam, A. M., & Ahmed, M. M. (2020). Effect of BMI on complications rate, reoperation and functional outcome after total knee arthroplasty: A systematic review of literature. *QJM: Monthly Journal of the Association of Physicians*, *113*(Supplement_1). https://doi.org/10.1093/qjmed/hcaa059.015

Almeida, G. J., Schroeder, C. A., Gil, A. B., Fitzgerald, G. K., & Piva, S. R. (2010). Interrater reliability and validity of the stair ascend/descend test in subjects with total knee arthroplasty. *Archives of Physical Medicine and Rehabilitation*, *91*(6), 932–938. https://doi.org/10.1016/j.apmr.2010.02.003

Arafa, A., Yasui, Y., Kato, Y., Matsumoto, C., & Kokubo, Y. (2024). The association between stair climbing and modifiable cardiovascular disease risk factors: The Suita Study. Environmental Health and Preventive Medicine, 29, 26–26. https://doi.org/10.1265/ehpm.23-00323

Archunan, M., Swamy, G., & Ramasamy, A. (2021). Stiffness after total knee arthroplasty: Prevalence and treatment outcome. *Curēus (Palo Alto, CA)*, *13*(9), e18271–e18271. https://doi.org/10.7759/cureus.18271

Bade, M. J., Kohrt, W. M., & Stevens-Lapsley, J. E. (2010). Outcomes before and after total knee arthroplasty compared to healthy adults. *The Journal of Orthopaedic and Sports Physical Therapy*, *40*(9), 559–567. https://doi.org/10.2519/jospt.2010.3317

Bedard, N. A., Dowdle, S. B., Wilkinson, B. G., Duchman, K. R., Gao, Y., & Callaghan, J. J. (2018). What is the impact of smoking on revision total knee arthroplasty? *Journal of Arthroplasty*, *33*(7), S172–S176. https://doi.org/10.1016/j.arth.2018.03.024

Bellemans, Johan., Ries, M. D., & Victor, J. M. K. (Eds.) (2005). Total knee arthroplasty: A guide to get better performance (1st ed. 2005.). *Springer Berlin Heidelberg.* https://doi.org/10.1007/3-540-27658-0

Bennell, K., Dobson, F., & Hinman, R. (2011). Measures of physical performance assessments: Self-paced walk test (SPWT), stair climb test (SCT), six-minute walk test (6MWT), chair stand test (CST), timed up & go (TUG), sock test, lift and carry test (LCT), and car task. *Arthritis Care & Research (2010)*, *63*(S11), S350–S370. https://doi.org/10.1002/acr.20538

Best, M. J., Buller, L. T., Gosthe, R. G., Klika, A. K., & Barsoum, W. K. (2015). Alcohol misuse is an independent risk factor for poorer postoperative outcomes following primary total hip and total knee arthroplasty. *Journal of Arthroplasty*, *30*(8), 1293–1298. https://doi.org/10.1016/j.arth.2015.02.028

Binkley, J. M., Stratford, P. W., Lott, S. A., & Riddle, D. L. (1999). The Lower Extremity Functional Scale (LEFS): Scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. *Physical Therapy*, *79*(4), 371–383.

Bonnefoy-Mazure, A., Martz, P., Armand, S., Sagawa, Y., Suva, D., Turcot, K., Miozzari, H. H., & Lübbeke, A. (2017). Influence of body mass index on sagittal knee range of motion and gait speed recovery 1-year after total knee arthroplasty. *Journal of Arthroplasty*, *32*(8), 2404–2410. https://doi.org/10.1016/j.arth.2017.03.008

Brock, T. M., Shirley, M., Bardgett, M., Walker, M., & Deehan, D. J. (2017). Inadequate pre-operative glycaemic control in patients with diabetes mellitus adversely influences functional recovery after total knee arthroplasty: Patients with impaired glycaemic control exhibit poorer functional outcomes at 1-year post-arthroplasty. *Knee Surgery,* *Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *25*(6), 1801–1806. https://doi.org/10.1007/s00167-016-4249-0

Campbell, T. M., Ghaedi, B. B., Ghogomu, E. T., Westby, M., & Welch, V. A. (2019). Effectiveness of stretching and bracing for the treatment of osteoarthritis-associated joint contractures prior to joint replacement: A systematic review protocol. *BMJ Open*, *9*(7), e028177–e028177. https://doi.org/10.1136/bmjopen-2018-028177

Capin, J. J., Bade, M. J., Jennings, J. M., Snyder-Mackler, L., & Stevens-Lapsley, J. E. (2022). Total knee arthroplasty assessments should include strength and performance-based functional tests to complement range of motion and patient reported outcome measures. *Physical Therapy*, *102*(6), 1–. https://doi.org/10.1093/ptj/pzac033

Christensen, J. C., Blackburn, B., Browning, B., Wilbur, C., Trinity, J. D., Gililland, J. M., & Pelt, C. E. (2023). Patient-reported outcomes measurement information system physical function and knee injury and osteoarthritis outcome score relationship on performance measures in people undergoing total knee arthroplasty. *Disability and Rehabilitation*, *ahead-of-print*(ahead-of-print), 1–9. https://doi.org/10.1080/09638288.2022.2134934

Cui, A., Li, H., Wang, D., Zhong, J., Chen, Y., & Lu, H. (2020). Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. *EClinicalMedicine*, *29–30*, 100587–100587. https://doi.org/10.1016/j.eclinm.2020.100587

Deng, Z., Jin, J., Li, M., Wang, S., Ma, Y., & Zheng, Q. (2021). Alcohol withdrawal is associated with worse outcomes in patients undergoing primary total knee or total hip arthroplasty. *Journal of Arthroplasty*, *36*(12), 3870-3877.e5. https://doi.org/10.1016/j.arth.2021.07.015

Franklin, P. D., Li, W., & Ayers, D. C. (2008). The Chitranjan Ranawat award: Functional outcome after total knee replacement varies with patient attributes. *Clinical Orthopaedics and Related Research*, *466*(11), 2597–2604. https://doi.org/10.1007/s11999-008-0428-8

Fransen, M., Nairn, L., Bridgett, L., Crosbie, J., March, L., Parker, D., Crawford, R., & Harmer, A. R. (2017). Post-acute rehabilitation after total knee replacement: A multicenter randomized clinical trial comparing long-term outcomes. *Arthritis Care & Research (2010)*, *69*(2), 192–200. https://doi.org/10.1002/acr.23117

French, H. P., Fitzpatrick, M., & FitzGerald, O. (2010). Responsiveness of physical function outcomes following physiotherapy intervention for osteoarthritis of the knee: An outcome comparison study. *Physiotherapy*, *97*(4), 302–308. https://doi.org/10.1016/j.physio.2010.03.002

Fritschi, C., Collins, E. G., O'Connell, S., McBurney, C., Butler, J., & Edwards, L. (2013). The effects of smoking status on walking ability and health-related quality of life in patients with peripheral arterial disease. *The Journal of cardiovascular nursing*, *28*(4), 380–386. https://doi.org/10.1097/JCN.0b013e31824af587

Gold, P. A., Garbarino, L. J., Anis, H. K., Neufeld, E. V., Sodhi, N., Danoff, J. R., Boraiah, S., Rasquinha, V. J., & Mont, M. A. (2020). The cumulative effect of substance abuse disorders and depression on postoperative complications after primary total knee arthroplasty. *Journal of Arthroplasty*, *35*(6), S151–S157. https://doi.org/10.1016/j.arth.2020.01.027

Gonçalves, R. S., Cabri, J., Pinheiro, J. P., Ferreira, P. L., & Gil, J. (2010). Reliability, validity and responsiveness of the Portuguese version of the Knee injury and osteoarthritis outcome score physical-function short-form (KOOS-PS). *Osteoarthritis and Cartilage*, *18*(3), 372–376. https://doi.org/10.1016/j.joca.2009.10.012

Gregg, E., Breckles, G., Williamson, D., Leveille, S., Langlois, J., Engelgau, M., & Narayan, K. (2000). Diabetes and physical disability among older U.S. adults. Diabetes Care, 23(9), 1272–1277. https://doi.org/10.2337/diacare.23.9.1272

Groen, J. W., Stevens, M., Kersten, R. F. M., Reininga, I. H., & Van Den Akker-Scheek, I. (2012). After total knee arthroplasty, many people are not active enough to maintain their health and fitness: An observational study. *Journal of Physiotherapy*, *58*(2), 113–116. https://doi.org/10.1016/S1836-9553(12)70091-7

Gromov, K., Jorgensen, C. C., Petersen, P. B., Kjaersgaard-Andersen, P., Revald, P., Troelsen, A., Kehlet, H., & Husted, H. (2019). Complications and readmissions following outpatient total hip and knee arthroplasty: A prospective 2-center study with matched controls. *Acta Orthopaedica*, *90*(3), 281–285. https://doi.org/10.1080/17453674.2019.1577049

Hatfield, G. L., Hubley-Kozey, C. L., Astephen Wilson, J. L., & Dunbar, M. J. (2011). The effect of total knee arthroplasty on knee joint kinematics and kinetics during gait. *Journal of Arthroplasty*, *26*(2), 309–318. https://doi.org/10.1016/j.arth.2010.03.021

Holm, P. M., Kemnitz, J., Bandholm, T., Wernbom, M., Schrøder, H. M., & Skou, S. T. (2020).

Muscle function tests as supportive outcome measures for performance-based and self-reported physical function in patients with knee osteoarthritis: Exploratory analysis of baseline data from a randomized trial. *Journal of Strength and Conditioning Research*, *36*(9), 2635–2642. https://doi.org/10.1519/JSC.0000000000003840

Hussein, H. M. E., Ibrahim, M. A. A., Rinaldi, M., Onabajo, M., & Cassella, C. (2021). Reflective parametric frequency-selective limiters with sub-dB Loss and µwatts power thresholds. *IEEE Transactions on Microwave Theory and Techniques*, *69*(6), 2989–3000. https://doi.org/10.1109/TMTT.2021.3072587

Jogi, P., Kramer, J. F., & Birmingham, T. (2005). Comparison of the Western Ontario and McMaster universities osteoarthritis index (WOMAC) and the lower extremity functional scale (LEFS) questionnaires in patients awaiting or having undergone total knee arthroplasty. *Physiotherapy Canada*, *57*(3), 208–216. https://doi.org/10.3138/ptc.57.3.208

Johnson, V. L., & Hunter, D. J. (2014). The epidemiology of osteoarthritis. *Best Practice & Research. Clinical Rheumatology*, *28*(1), 5–15. https://doi.org/10.1016/j.berh.2014air .01.004

Kane, R. L., Saleh, K. J., Wilt, T. J., & Bershadsky, B. (2005). The Functional Outcomes of Total Knee Arthroplasty. *Journal of Bone and Joint Surgery. American Volume*, *87*(8), 1719–1724. https://doi.org/10.2106/JBJS.D.02714

Kelly, M. A., Finley, M., Lichtman, S. W., Hyland, M. R., & Edeer, A. O. (2016). Comparative analysis of high-velocity versus low-velocity exercise on outcomes after total knee arthroplasty: A randomized clinical trial. Journal of Geriatric Physical Therapy (2001), 39(4), 178–189. https://doi.org/10.1519/JPT.0000000000000070x

Kennedy, D. M., Stratford, P. W., Riddle, D. L., Hanna, S. E., & Gollish, J. D. (2008). Assessing recovery and establishing prognosis following total knee arthroplasty. *Physical Therapy*, *88*(1), 22–32. https://doi.org/10.2522/ptj.20070051

King, L. K., Hawker, G. A., Stanaitis, I., Woodhouse, L., Jones, C. A., & Waugh, E. J. (2022). Minimal clinically important difference for improvement in six-minute walk test in persons with knee osteoarthritis after total knee arthroplasty. *BMC musculoskeletal disorders*, *23*(1), 307. https://doi.org/10.1186/s12891-022-05262-4

King, L. K., Waugh, E. J., Jones, C. A., Bohm, E., Dunbar, M., Woodhouse, L., Noseworthy, T., Marshall, D. A., Hawker, G. A., & BEST-Knee Study Team (2021). Comorbidities do not limit improvement in pain and physical function after total knee arthroplasty in patients with knee osteoarthritis: The BEST-Knee prospective cohort study. *BMJ open*, *11*(6), e047061. https://doi.org/10.1136/bmjopen-2020-047061

Kopf, S., Musahl, V., Tashman, S., Szczodry, M., Shen, W., & Fu, F. H. (2009). A systematic review of the femoral origin and tibial insertion morphology of the ACL. Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA, 17(3), 213–219. https://doi.org/10.1007/s00167-008-0709-5

Landin, D., Thompson, M., & Reid, M. (2016). Actions of two bi-articular muscles of the lower extremity: A Review. Journal of Clinical Medicine Research, 8(7), 489–494. https://doi.org/10.14740/jocmr2478w

Lange-Maia, B. S., Karvonen-Gutierrez, C. A., Strotmeyer, E. S., Avery, E. F., Appelhans, B. M., Fitzpatrick, S. L., Janssen, I., Dugan, S. A., & Kravitz, H. M. (2019). Factors influencing longitudinal stair climb performance from midlife to early late life: The study of women's health across the nation chicago and michigan sites. The Journal of Nutrition, Health & Aging, 23(9), 821–828. https://doi.org/10.1007/s12603-019-1254-2

Lavernia, C. J., Villa, J. M., & Contreras, J. S. (2013). Arthroplasty knee surgery and alcohol use: Risk factor or benefit? Clinical Orthopaedics and Related Research, 471(1), 189–194. https://doi.org/10.1007/s11999-012-2490-5

Lin, Y., Hu, X., Cao, Y., Wang, X., Tong, Y., Yao, F., Wu, P., & Huang, H. (2021). The role of 6-minute walk test guided by impedance cardiography in the rehabilitation following knee arthroplasty: A randomized controlled trial. Frontiers in Cardiovascular Medicine, 8. https://doi.org/10.3389/fcvm.2021.736208

Logterman, S. L., Wydra, F. B., & Frank, R. M. (2018). Posterior cruciate ligament: Anatomy and biomechanics. *Current Reviews in Musculoskeletal Medicine*, *11*(3), 510–514. https://doi.org/10.1007/s12178-018-9492-1

Londhe, S. B., Shah, R. V., Patwardhan, M., Doshi, A. P., Londhe, S. S., Subhedar, K., Kundnani, V., & Patel, J. (2021). Study of patients with bilateral knee osteoarthritis undergoing total knee replacement procedure with coexisting lumbar spondylosis symptoms. *Asian Spine Journal*, *15*(6), 825–830. https://doi.org/10.31616/asj.2020.0279

Lungu, E., Desmeules, F., Dionne, C. E., Belzile, E. L., & Vendittoli, P.-A. (2014). Prediction of poor outcomes six months following total knee arthroplasty in patients awaiting surgery. *BMC Musculoskeletal Disorders*, *15*(1), 299–299. https://doi.org/10.1186/1471-2474-15-299

Marchant, M. H., Tibor, L. M., Sekiya, J. K., Hardaker, W. T., Garrett, W. E., & Taylor, D. C.

(2011). Management of medial-sided knee injuries, part 1: Medial collateral ligament. *American Journal of Sports Medicine*, *39*(5), 1102–1113. https://doi.org/10.1177/036354651038599

Masaracchio, M., Hanney, W. J., Liu, X., Kolber, M., & Kirker, K. (2017). Timing of rehabilitation on length of stay and cost in patients with hip or knee joint arthroplasty: A systematic review with meta-analysis. *PloS One*, *12*(6), e0178295–e0178295. https://doi.org/10.1371/journal.pone.0178295

Meister, B. R., Michael, S. P., Moyer, R. A., Kelly, J. D., & Schneck, C. D. (2000). Anatomy and kinematics of the lateral collateral ligament of the knee. *American Journal of Sports Medicine*, *28*(6), 869–878. https://doi.org/10.1177/03635465000280061601

Melliti, W., Kammoun, R., Masmoudi, D., Ahmaidi, S., Masmoudi, K., Alassery, F., Hamam, H., & Chlif, M. (2021). Effect of six-minute walk test and incremental exercise on inspiratory capacity, ventilatory constraints, breathlessness and exercise performance in sedentary male smokers without airway obstruction. *International Journal of Environmental Research and Public Health*, *18*(23), 12665-. https://doi.org/10.3390/ijerph182312665

Mendelson, M., Michallet, A.-S., Perrin, C., Levy, P., Wuyam, B., & Flore, P. (2014). Exercise training improves breathing strategy and performance during the six-minute walk test in obese adolescents. Respiratory Physiology & Neurobiology, 200, 18–24. https://doi.org/10.1016/j.resp.2014.05.004

Mizner, R. L., Petterson, S. C., Clements, K. E., Zeni, J., Irrgang, J. J., & Snyder-Mackler, L. (2011). Measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments: A longitudinal analysis of outcomes. *Journal of Arthroplasty*, *26*(5), 728–737. https://doi.org/10.1016/j.arth.2010.06.004

Naal, F. D., Impellizzeri, F. M., Torka, S., Wellauer, V., Leunig, M., & von Eisenhart-Rothe, R. (2015). The German lower extremity functional scale (LEFS) is reliable, valid and responsive in patients undergoing hip or knee replacement. *Quality of Life Research*, *24*(2), 405–410. https://doi.org/10.1007/s11136-014-0777-6

Oatis, C. A., Johnson, J. K., DeWan, T., Donahue, K., Li, W., & Franklin, P. D. (2019). Characteristics of usual physical therapy post-total knee replacement and their associations with functional outcomes. *Arthritis Care & Research (2010)*, *71*(9), 1171–1177. https://doi.org/10.1002/acr.23761

Ozden, F., & Tumturk, I. (2022). Performance-based outcome measures in total knee arthroplasty: A systematic review. *Physical & Occupational Therapy in Geriatrics*, *40*(3), 241–260. https://doi.org/10.1080/02703181.2021.2015048

Paradowski, P. T., Kęska, R., & Witoński, D. (2015). Validation of the polish version of the knee injury and osteoarthritis outcome score (KOOS) in patients with osteoarthritis undergoing total knee replacement. *BMJ Open*, *5*(7), e006947–e006947. https://doi.org/10.1136/bmjopen-2014-006947

Pasupathi, P., Bakthavathsalam, G., Rao, Y. Y., & Farook, J. (2009). Cigarette smoking—effect of metabolic health risk: A review. *Diabetes & Metabolic Syndrome Clinical Research & Reviews*, *3*(2), 120–127. https://doi.org/10.1016/j.dsx.2009.02.006

Podmore, B., Hutchings, A., van der Meulen, J., Aggarwal, A., & Konan, S. (2018). Impact of comorbid conditions on outcomes of hip and knee replacement surgery: A systematic review and meta-analysis. *BMJ Open*, *8*(7), e021784–e021784. https://doi.org/10.1136/bmjopen-2018-021784

Pourmoghaddam, A., Dettmer, M., Malanka, S., & Kreuzer, S. (2016). Comparison of functional outcomes of total knee arthroplasty using two different single radius implants. *Reconstructive Review*, *6*(1). https://doi.org/10.15438/rr.6.1.134

Repo, J. P., Tukiainen, E. J., Roine, R. P., Ilves, O., Järvenpää, S., & Häkkinen, A. (2017). Reliability and validity of the Finnish version of the lower extremity functional scale (LEFS). *Disability and Rehabilitation*, *39*(12), 1228–1234. https://doi.org/10.1080/09638288.2016.1193230\

Ronai, P., & Gallo, P. M. (2020). The stair climb power test. *ACSM's Health & Fitness Journal*, *24*(4), 38–42. https://doi.org/10.1249/FIT.0000000000000589

Rotevatn, T. A., Bøggild, H., Olesen, C. R., Torp-Pedersen, C., Mortensen, R. N., Jensen, P. F., & Overgaard, C. (2017). Alcohol consumption and the risk of postoperative mortality and morbidity after primary hip or knee arthroplasty: A register-based cohort study. *PloS One*, *12*(3), e0173083–e0173083. https://doi.org/10.1371/journal.pone.0173083

Roth, A., Khlopas, A., George, J., Churchill, J. L., Molloy, R., Mont, M. A., Piuzzi, N. S., & Higuera, C. A. (2019). The effect of body mass index on 30-day complications after revision total hip and knee arthroplasty. *Journal of Arthroplasty*, *34*(7), S242–S248. https://doi.org/10.1016/j.arth.2019.02.005

Saleh, K. J. Mulhall, K. J., Bershadsky, B., Ghomrawi, H. M., White, L. E., Buyea, C. M., & Krackow, K. A. (2005). Development and validation of a lower-extremity activity scale: Use for patients treated with revision total knee arthroplasty. *Journal of Bone and Joint*

Surgery. American Volume, *87A*(9), 1985–1994. https://doi.org/10.2106/00004623-200509000-00011

Seil, R., & Pape, D. (2011). Causes of failure and etiology of painful primary total knee arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *19*(9), 1418–1432. https://doi.org/10.1007/s00167-011-1631-9

Sharma, S., Wilson, R., Pryymachenko, Y., Pathak, A., Chua, J., Gwynne-Jones, D., Bennell, K. L., Metcalf, B., Hinman, R. S., Hunt, M. A., Lim, B., & Abbott, J. H. (2023). Reliability, validity, responsiveness, and minimum important change of the stair climb test in adults with hip and knee osteoarthritis. *Arthritis Care & Research (2010)*, *75*(5), 1147–1157. https://doi.org/10.1002/acr.24821

Singh, J. A. (2011). Epidemiology of knee and hip arthroplasty: A systematic review. *Open Orthopaedics Journal*, *5*(1), 80–85. https://doi.org/10.2174/1874325001105010080

Steinhoff, A. K., & Bugbee, W. D. (2016). Knee Injury and osteoarthritis outcome score has higher responsiveness and lower ceiling effect than knee society function score after total knee arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *24*(8), 2627–2633. https://doi.org/10.1007/s00167-014-3433-3

Stevens-Lapsley, J. E., Schenkman, M. L., & Dayton, M. R. (2011). Comparison of self-reported knee injury and osteoarthritis outcome score to performance measures in patients after total knee arthroplasty. *Physical Medicine and Rehabilitation, 3*(6), 541–549. https://doi.org/10.1016/j.pmrj.2011.03.002

Strotmeyer, E., Lui, L.-Y., Glynn, N. W., Santanasto, A., Kritchevsky, S., Cawthon, P., Newman, A., & Cauley, J. (2022). Stair climb time and functional power associations to muscle function and physical performance. Innovation in Aging, 6(Supplement_1), 302–302. https://doi.org/10.1093/geroni/igac059.1195

Turcotte, J. J., Kelly, M. E., Fenn, A. B., Grover, J. J., Wu, C. A., & MacDonald, J. H. (2022). The role of the lower extremity functional scale in predicting surgical outcomes for total joint arthroplasty patients. *Arthroplasty*, *4*(1), 3–3. https://doi.org/10.1186/s42836-021-00106-3

Vancampfort, D., Hallgren, M., Vandael, H., Probst, M., Van Hoof, P., Firth, J., & Van Damme, T. (2020). Functional exercise capacity in inpatients with alcohol use disorder versus healthy controls: A pilot study. Alcohol (Fayetteville, N.Y.), 82, 47–52. https://doi.org/10.1016/j.alcohol.2019.07.006

Wei, G., Shang, Z., Li, Y., Wu, Y., & Zhang, L. (2024). Effects of lower-limb active resistance exercise on mobility, physical function, knee strength and pain intensity in patients with total knee arthroplasty: A systematic review and meta-analysis. BMC Musculoskeletal Disorders, 25(1), 730–17. https://doi.org/10.1186/s12891-024-07845-9

Wellman, S. S., Klement, M. R., & Queen, R. M. (2017). Performance comparison of single-radius versus multiple-curve femoral component in total knee arthroplasty: A prospective, randomized study using the lower quarter Y-Balance Test. *Orthopedics (Thorofare, N.J.)*, *40*(6), E1074–E1080. https://doi.org/10.3928/01477447-2017102002

Young, J. J., Perruccio, A. V., Veillette, C. J. H., McGlasson, R. A., & Zywiel, M. G. (2023). The GLA:D® Canada program for knee and hip osteoarthritis: A comprehensive profile of program participants from 2017 to 2022. *PloS One*, *18*(8), e0289645–e0289645. https://doi.org/10.1371/journal.pone.0289645

Yue, C. C., Cui, G. G., Ma, M. M., Tang, Y. Y., Li, H. H., Liu, Y. Y., & Zhang, X. X. (2022).

Associations between smoking and clinical outcomes after total hip and knee arthroplasty: A systematic review and meta-analysis. *Frontiers in Surgery*, *9*. https://doi.org/10.3389/fsurg.2022.970537

Appendix A

Research Ethics Board Approval Form

Research Ethics Board

June 1, 2022

Dr. David Puskas dpuskas@tbaytel.net
Big Thunder Orthopedics
984 Oliver Road, Suite 206
Thunder Bay, ON P7B 7C7

Re:	**Project Number:**	TBRHSC REB #: 2022509
	Project Title:	Predictors of functional outcomes following total hip and knee arthroplasty utilizing performance-based tests
	REB Expiry Date:	01-Jun-2023

Dear Dr. Puskas,

Thank you for your submission to the Thunder Bay Regional Health Sciences Centre Research Ethics Board (TBRHSC REB). The above noted application has been reviewed and approved through the delegated review process for the TBRHSC REB. **TBRHSC REB approval is granted based on the following documentation:**

- REB Application v2 dated 31-May-2022
- Protocol v2 dated 28-Mar-2022
- Telephone Script v1 dated 22-Jan-2022
- Information Letter & Consent v2 dated 28-Mar-2022
- Case Report Form v1 dated 22-Jan-2022
- SOP's for Functional Tests v1 dated 22-Jan-2022
- Project Budget v1
- NOAMA Approval of Funding Letter

The delegated approval for this study will be reported to the full REB at their next meeting. TBRHSC REB is guided by the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans 2018 and ICH: Good Clinical Practice (GCP) guidelines.

In addition to this TBRHSC REB approval, all projects at TBRHSC require Research Program review. Prior to beginning your REB approved project, research teams must receive written notification for final project authorization from the Research Program.

Continuing ethics review is the responsibility of the Principal Investigator. During the course of your research, any serious adverse events, changes in the approved protocol, consent form or other information needs to be submitted for review to the REB using the appropriate forms. REB approval is required should your project extend beyond the approval period noted above. Upon completion/termination of the study you are required to submit a Study Completion Report. All forms are available at:

http://www.tbrhsc.net/about_TBRHSC/research_ethics/forms.asp

...2

Yours Sincerely,

01-Jun-2022

Bill Gregorash, BA, MA, PhD Management
Chair, TBRHSC REB

Date

The TBRHSC Research Ethics Board operates in compliance with and is constituted in accordance with the requirements of:

- TCPS 2 - 2018 Edition of the Tri-Council Policy Statement: Ethical conduct for Research Involving Humans,
- ICH Good Clinical Practice: Consolidated Guideline - ICH E6(R3)
- Part C division 5 of the food and drug regulations of Health Canada dated 21-Aug-2019, and
- The provisions of the Ontario Health Information Protection Act 2004 dated 19-Apr-2021 and its applicable regulations
- TBRHSC REB is registered with the US department of Health and Human services under IRB registration #00004396

Research Ethics & Authorization Office

Room 2167 – Level 2
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Tel.: (807) 684-6422
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Description of Research Team

Principal Investigator:	Dr. David Puskas Big Thunder Orthopedics 984 Oliver Road, Suite 206 Thunder Bay, ON P7B 7C7 807-344-1123 dpuskas@tbaytel.net
Qualified Investigator:	N/A
Co-Investigator(s):	Dr. Simon Lees Medical Sciences Division Northern Ontario School of Medicine 955 Oliver Road Thunder Bay, ON P7B 5E1 807-766-7435 Simonjlees@gmail.com
	Dr. Paolo Sanzo Kinesiology, Lakehead University 955 Oliver Road Thunder Bay, ON P7B 5E1 psanzo@lakeheadu.ca
	Mr. Bruce Weaver Biostatistics Northern Ontario School of Medicine 955 Oliver Road Thunder Bay, ON P7B 5E1 bweaver@lakeheadu.ca

Research Ethics Board

-3-

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Appendix B

Phone Script

Protocol Number		**REB approval date**	/ /
Project Title	Predictors of functional outcomes following total hip and knee arthroplasty utilizing performance-based tests		
Principal Investigator	Dr. David Puskas		

B. Telephone script

STEP 1 | INITIAL CONTACT

Date of Phone Call	
Member of Research Team Completing Phone Call	

Section	Script	Check as Completed
Introduction	Hello. I am first name and surname from the Thunder Bay Regional Health Sciences Centre. May I please speak to insert potential participant's name.	
When desired person is on the phone	I am calling you about a research project which aims to identify factors that contribute to improved surgical outcomes following total knee or hip replacement. We received your contact information from the scheduling clerks from Big Thunder Orthopaedics, who asked you if a member of our research team could call you. If you are interested in finding out more about this research project, I can give you more details now over the phone. If you decide you do not want to continue this phone call, or if you do not want to participate in the research project, it will not affect your care or any future care you may have at the Thunder Bay Regional Health Sciences Centre. Is now a good time to talk more about the research project? **IF NO, GO TO STEP 2a** **IF YES, GO TO STEP 2b**	
If desired person is not available	Is there a better day and time to reach [Mr/Mrs]_________? Note days and times and enter into the bottom of this phone script. Thank you for your assistance. I will try to call back then.	

STEP 2 | PROJECT DESCRIPTION

Section	Script	Check as Completed
STEP 2a **If interrupted or strong immediate refusal**	Is there another time I can call you back? **IF YES**, Thank you. I will try to call back then. Note days and times and enter into the bottom of this phone script. **IF NO/NOT INTERESTED**. Okay. Thank you for your time. **End Call.**	
STEP 2b **If not interrupted**	Researchers at Big Thunder Orthopaedics want to determine which factors influence surgical outcomes and improved physical function following surgery. The overall aim of the study is to establish evidence to support the future design of enhanced strategies to improve these patient outcomes. Would you like me to explain what we will need you to do to participate in this study?	

Version 1.0 Jan 22, 2022 Page 1 of 3

	IF NO/NOT INTERESTED. Okay. Thank you for your time. **IF YES, GO TO STEP 3a**	

STEP 3 | PARTICIPATION DETAILS

Section	Script	Check as Completed
STEP 3	We will be using data collected from patient charts in combination a variety of functional tests aimed at determining your ability to walk and climb stairs. In addition, there will be self-assessment forms used to determine your pain, stiffness and functional ability as well as a patient satisfaction survey. These tests will be done on 2 study visits, one before your surgery and one 6 months after. Each study visit will occur at Lakehead University and will take about 1 hour. While there is no direct benefit to you as a potential participant in the study, you may gain a deeper understanding of your functional abilities before and after surgery by learning the results of the functional tests. In addition, after completing the study, you will be offered a $50 gift card. Would you like me to proceed? **IF YES**, Proceed to **STEP 4** **IF NO/NOT INTERESTED**. Okay. Thank you for your time. **End Call.**	

STEP 4 | USE OF INFORMATION

Section	Script	Check as Completed
STEP 4	Thank you. I will now briefly explain how we will use your information. Your health information and data will be kept confidential throughout the study. A key will be created with a list of participant names and their unique codes. This key will be kept in an encrypted document on a secure computer. Only members of the research team will have access to the data, and any publication of the study results will use aggregate data so no individual person can be identified. Proceed to **STEP 5a**	

STEP 5 | DETAILS FOR SENDING THE INFORMATION LETTER

Section	Script	Check as Completed
STEP 5a	I would like to send you a copy of the study information for you to review prior to your first study visit and consenting to the study. Is there an email address I can use to send you this information **IF YES** Fill in below and then proceed to **STEP 6** **IF NO** Proceed to **STEP 5b** email address:	

STEP 5b	Is there a mailing address that you would prefer I use? **IF YES** Fill in below and proceed to **STEP 6** **IF NO** We can give you a copy of this information to review at your first visit prior to consenting to the study. Mailing address:	

STEP 6 | ENDING THE CALL

Section	Script	Check as Completed
STEP 6	I would like to contact you again in a couple of days to set up a study visit. Would you prefer me to reach you by phone or email? **IF PHONE**, what is the preferred phone number? **IF EMAIL**, confirm the email address above Proceed to **STEP 6b** **IF NO,** Proceed to **STEP 6c**	
STEP 6b	Thank you again for your time and interest in our research project. Do you have any questions? Again, my name is first name. If you have any questions after this phone call you can contact me by phone [insert phone number]. Thank you for your time today. Goodbye. **End Call.**	
STEP 6c	**IF NO/NOT INTERESTED**. Okay. Thank you for your time. **End Call.**	

EXTRA NOTES FROM CALL (i.e. other times to call back, etc)

FOLLOW UP CALL | INFORMATION TO CONVEY

1. Schedule a day and time for Study visit 1
2. Meet at the front desk of the Lakehead Recreation Facility, C.J. Sanders Fieldhouse [send a campus map]
3. You will have to pay for parking, but you will be reimbursed
4. Wear or bring shoes and clothing that you will be comfortable walking on an indoor track and ascending and descending stairs. There are changing facilities available

Appendix C

Information Form

Version 1.1 March 28, 2022

Thunder Bay Regional Health Sciences Centre

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TBRHSC
01-Jun-2022
REB

Principal Investigator:	Dr. David Puskas Big Thunder Orthopedic Associates Associate Professor, Northern Ontario School of Medicine (NOSM) (807) 344-1123
Co-Investigators	Dr. Simon Lees, Professor, NOSM, Medical Sciences Division Dr. Paolo Sanzo Associate Professor, NOSM and Lakehead University, School of Kinesiology Dr. Kurt Droll Big Thunder Orthopedic Associates Associate Professor, (NOSM) Dr. Claude Cullinan Big Thunder Orthopedic Associates Associate Professor, (NOSM) Dr. Travis Marion Assistant Professor, NOSM Mr. Bruce Weaver Assistant Professor, Biostatistics, NOSM
Funding provided by:	Northern Ontario Academic Medical Association (NOAMA)
Study title:	Predictors of functional outcomes following total hip and knee arthroplasty utilizing performance-based tests

Dear potential participant:

You are being invited to participate in the following study being conducted by Dr. David Puskas, Dr. Claude Cullinan, Dr. Kurt Droll, Dr. Travis Marion, Dr. Paolo Sanzo, Mr. Bruce Weaver, and Dr. Simon Lees to identify factors that contribute to improved surgical outcomes following total knee or hip replacement. Please keep in mind that this is an invitation, and by no means are you required to participate. This study has been funded through the Northern Ontario Academic Medical Association (NOAMA) through their Clinical Innovation Opportunities Fund. This project is expected to occur over a two year period. We have asked you to participate because you are booked to receive a unilateral total knee or total hip replacement surgery, are in the Thunder Bay and surrounding area, and are within

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18-85 years of age. In order to decide whether or not you want to be a part of this research study, you should understand what is involved and the potential risks and benefits. This document gives you detailed information about the research study.

Why is this study being done?
Researchers at Big Thunder Orthopedic Associates, the Northern Ontario School of Medicine, and Lakehead University want to determine which factors influence surgical outcomes and improved physical function following surgery. The overall aim of the study is to establish evidence to support the future design of enhanced strategies to improve these patient outcomes. We will be using data collected from patient charts in combination with a variety of other functional tests aimed at determining your ability to walk and climb stairs. In addition, there will be self-assessment forms used to determine your pain, stiffness, and functional ability as well as a patient satisfaction survey. These tests will be done on 2 study visits, one before your surgery and one 6 months after. Each study visit will occur at Lakehead University and will take about 1 hour.

Benefits to society?
This study will allow for better patient-centred care. The outcomes of this project will allow for the TBRHSC to develop future strategies to enhance recovery and patient outcomes following total joint arthroplasty. The Thunder Bay area will likely see more demand for total joint arthroplasties in the future as the population ages, so enhanced recovery and positive patient outcomes will be critical in allowing for these surgeries to occur.

What will happen during this study?
If you participate in this research study you will be asked to complete 2 study visits on the campus of Lakehead University. Both of these study visits are expected to take about 1 hour. You will be reimbursed for the cost of parking on campus for the time required for these visits. Study visit #1 will take place prior to your joint replacement surgery. Study visit #2 will take place about 6 months after your joint replacement surgery. A participant satisfaction survey will also be completed at the end of the second visit.

Both study visits will include tests of functional ability including the: 1) stair climb test, 2) stair climb power test, 3) 6-minute walk test, 4) the completion of the Lower Extremity Functional Scale, and 5) the Western Ontario and McMaster Universities Osteoarthritis Index.

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Stair Climb Test assesses the ability of the participant to ascend and descend a flight of stairs. The typical test sets the number of stairs at 12 steps. This tests the lower body strength and balance of the participant and the ability to navigate a real-world activity

Stair Climb Power is similar to the Stair Climb Test above, except that "power" will be computed based on the time it takes to climb a flight of stairs.

Please note: Both of the tests involving stairs will have a spotter to follow you during these tests to minimize the risk of falling. You will be able to use any walking aid that you normally use.

6-Minute Walk Test measures the distance that you can walk in 6 minutes. It is a test of aerobic capacity that will also test your balance and mobility over a long-distance. We will perform this test at the Lakehead University Hanger on the indoor track.

Lower Extremity Functional Scale is a self-administered tool completed by the participant which scores the functional status of their lower limbs during typical activities

Western Ontario and McMaster Universities Osteoarthritis Index is a set of standardized questions that evaluate the physical function of patient's knee and hip joints in patients with osteoarthritis.

Other information that is collected:
In addition to the tests described above, we will collect information from your patient chart. This information includes sex, age (years), height (cm), weight (kg), type of surgery, alcohol consumption, smoking, and comorbidities. This information is collected during the normal standard of care visits for orthopedic patients.

What are the risks or harms of participating in this study?
While the functional tests are designed to be applicable to everyday activities, there is minimal risk in performing the functional outcome tests. In order to minimize these risks further, you will be instructed to do the best you can by going as fast as you can but not to push yourself to a point of overexertion or beyond what you think is safe. In addition, the tester will follow you as a spotter for the tests involving stairs. Moreover, these risks will be reduced by allowing the use of your walking aid, if preferred. The loss of privacy (as a social risk) is always a possibility, however, this risk will be minimized by creating a participant identifier number

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which will be in an encrypted file on a password-protected computer.

What are the possible benefits for me?
While there is no direct benefit to you as a potential participant in the study, you may gain a deeper understanding of your functional abilities before and after surgery by learning the results of the functional tests.

Are study participants paid to participate in this study?
There will be no prorated payments, that is a specific payment rate based on the time you spend during the study visits, however, parking costs for study visits at Lakehead University will be reimbursed. Upon completion of the study, you will be offered a $50 gift card.

Can participation in this study end early?
Your participation in this study may end early if you choose to withdraw for any reason. If you wish to withdraw consent from the study, you will be asked to specify if you wish for any data collected to be withdrawn as well. Data will be withdrawn in accordance with your wishes. You are under no obligation to participate in this study, and you may choose to withdraw from it at any point by contacting Dr. Simon Lees (807-766-7435), the primary contact for this study. During the course of the research project, you will be given all information that is relevant to your decision to continue or withdraw from the study, as well as information on your right to request the withdrawal of collected data.

What happens if I have a research related injury?
There is no compensation or insurance coverage for research-related injuries, however, we do not anticipate any to occur during your participation in this study. Please note that by consenting to participate in this study, you have not waived any rights to legal recourse in the event of research-related harm.

How will my information be kept confidential?
As described above, all personal data (test scores and patient information) that are collected will be de-identified through a coding process, and only the research team will have access to this data and the samples. Collected hard copies of the data will be stored in a secure file cabinet in a locked office. Computer data will be kept on a secure server on a password protected computer. All data will be stored for a minimum of five years. When the study is finished, we will write up our aggregate results, that is, data which is combined and summarized so that no individual participant can be identified in manuscripts. These manuscripts may then be published in academic journals. We will also present our results at academic conferences. If you are interested in the results

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Centre

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of the study, we can arrange to have those results sent to you. Please ask a member of our team; we would be happy to provide them to you. The research team, as well as the research ethics board at TBRHSC will be granted access to the information you provide and data collected as a result of your participation in this study without violating your confidentiality to the extent permitted by the applicable laws and regulations.

Do the investigators have any conflicts of interest?
There will be no commercialization of the study findings by the researchers. There are no real, potential, or perceived conflicts of interest on the part of the researchers, their institutions, or the research sponsors. None of the research team members will receive a fee for your enrollment.

COVID-19 Protection Plan
Due to the COVID-19 pandemic, in-person research carries additional risk. During the period of time that requires COVID-19 precautions, all researchers and participants will follow the provisions required by Lakehead University. These may include masks (which will be provided) proof of vaccination, and logs for the purposes of contact tracing. The logs will document your name and telephone number. If a research team member or research participant(s) contracts COVID-19, the log would be shared with health authorities if requested. Only your name and telephone number, and not the reason for contact, would be shared with health authorities. Your information will be combined with all other contacts and you will not be identified as a participant in this research study. Contact logs would only be kept for the period of time that is required at the time of your participation, then all identifying information is destroyed.

Who do I contact If I have any questions or problems?
If you have any questions regarding this study, please feel free to contact the research team. The primary contact for this study is Dr. Simon Lees and he can be reached at 807-766-7435 or vial email at simon.lees@nosm.ca. This project has been approved by the research ethics board at TBRHSC. If you have any concerns regarding your rights as a research participant or wish to speak to someone other than a research team member about this research project, you are welcome to contact the:

Chair, Research Ethics Board
Thunder Bay Regional Health Sciences Centre
Phone: 807-684-6422
Email contact for REB: TBR_REO@tbh.net

Version 1.1 March 28, 2022

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We understand that you may need some time to consider your participation, so please take the time you need to assimilate the information provided, pose any questions you may have, and discuss and consider whether you will participate.

We thank you for your time,

Dr. David Puskas
Dr. Paolo Sanzo
Dr. Claude Cullinan
Mr. Bruce Weaver
Dr. Simon Lees
Dr. Travis Marion
Dr. Kurt Droll

Appendix D

Consent Form

Version 1.1 Mar 28, 2022

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Research Participant Information and Consent Form

Predictors of functional outcomes following total hip and knee arthroplasty utilizing performance-based tests

Research Participant's Consent

I have read the consent form and have had the details of the study explained to me. All of my questions have been answered satisfactorily. I understand that I am free now, and in the future, to ask any questions about the study.

By signing this form, I confirm that:

- This research study has been fully explained to me and all of my questions answered to my satisfaction
- I understand the requirements of participating in this research study
- I have been informed of the risks and benefits, if any, of participating in this study
- I have been informed that by consenting, I have not waived any rights to legal recourse in the event of research-related harm
- I have been informed that there is no compensation or insurance coverage for research-related injuries
- I have been informed of any alternatives to participating in this research study
- I have been informed of the rights of research participants
- I have read each page of this form
- I authorize access to my personal health information and research study data as explained in this form
- I have agreed to participate in this research study
- I understand that I am a volunteer, I am free to withdraw at any time without any effect to my current or future health care at TBRHSC, and I may choose not to answer any question asked of me
- I understand that the data I provide will be securely stored for a minimum of 5 years following completion of the study
- I understand that I will remain anonymous in any publication/public presentation of the research findings

Version 1.1 Mar 28, 2022

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Signature of Research Participant

Initial Consent

____________________	_____________________	_____/______/_____
Name of Research Participant (print)	Signature of Research Participant	Day/Month/Year

Name of participant's primary care physician/healthcare provider:

____

6 month post-surgery study visit

____________________	_____________________	_____/______/_____
Name of Research Participant (print)	Signature of Research Participant	Day/Month/Year

Signature of Person Obtaining Consent
I have explained the terms of this information and consent form to the research participant and I have answered the questions he/she asked me.
Initial Consent

_____________________	_____________________	_____/______/_____
Name of Person	Signature of Person	Day Month Year

6 month post-surgery study visit

_____________________	_____________________	_____/______/_____
Name of Person	Signature of Person	Day Month Year

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Statement of the Investigator

The lead investigator (Dr. Puskas) acknowledges his responsibility for the care and well-being of the above participant, to respect the rights and wishes of the participant as described in this informed consent document, and to conduct this study according to all applicable laws, regulations and guidelines relating to the ethical and legal conduct of research.

If you have any questions or comments, please contact Dr. Simon Lees (807-766-7435; simon.lees@nosm.ca).

If you have any concerns regarding your rights as a research participant, or wish to speak to someone other than a research team member about this research project, you are welcome to contact the Research Ethics Boards:

Chair, Research Ethics Board
Thunder Bay Regional Health Sciences Centre
Phone: 807-684-6422 Fax: 807-684-5904
Email contact for REB: TBR_REO@tbh.net

Appendix E

Case Report Form

Participant ID: ____________

VISIT 1: FIRST VISIT

Date of Visit (dd-mmm-yyyy): ______________________
Consent Date (dd-mmm-yyyy): ______________________

Eligibility Screening	
Screening completed; eligibility confirmed	☐ Yes ☐ No (do not enroll)
Demographics and medical history – collected from Meditech or participant reported	
Date of Birth (mm/yyyy)	
Age (years)	
Sex	☐ Male ☐ Female
Height (cm)	
Weight (kg)	
BMI (kg/m^2)	
Smoking status	☐ Current every day smoker ☐ Current some day smoker ☐ Former smoker ☐ Never smoker ☐ Unknown
Alcohol intake	☐ Never ☐ Occasionally (<1/day) ☐ Daily ☐ Unknown

Comorbidities (As determined at pre-operative visit, select all that apply)	☐ Diabetes
	☐ History of cancer
	☐ Hypertension
	☐ Cardiovascular:
	    ☐ Arrhythmia
	    ☐ PVD
	    ☐ Other: ________________________
	☐ Pulmonary:
	    ☐ Asthma
	    ☐ COPD
	☐ Prior stroke/TIA
	☐ Other: ____
	☐ None

Signature of person completing form: ________________________ Date: _____________________________

Participant ID: ____________

Geographic location	☐ Thunder Bay ☐ NWO regional ☐ Outside of NWO ☐ Unknown		
Type of Surgery	☐ Hip ☐ Knee Unilateral? Y / N		
Surgery Date (dd-mmm-yyyy)			
Questionnaires			
WOMAC	Pain Score: _____/20 Stiffness Score: _____/8 Physical Function Score: _____/68 **Total Score: _____/96**	LEFS	**Final score: _____/100**
Functional Tests			
Stair Climb Test	Use of handrail?: Y / N		
Stair Climb Power Test	Time to go up the stairs:___________ Stair Climb Power Calculation Result: _________		
6-Minute Walking Test			
Was a walking aid used in any of the above functional tests?	Y / N If yes, which tests?____		

Signature of person completing form: ________________________ Date: _____________________________
Case Report Form V1.0: Jan 22, 2022 Page 2 of 3

Participant ID: ____________

VISIT 2: 6-MONTH FOLLOW-UP VISIT

Date of Visit (dd-mmm-yyyy): ______________________

Questionnaires			
WOMAC	Pain Score: _____/20 Stiffness Score: _____/8 Physical Function Score: _____/68 **Total Score: _____/96**	LEFS	**Final score: _____/100**
Functional Tests			
Stair Climb Test	Use of handrail?: Y / N		
Stair Climb Power Test	Time to go up the stairs:___________ Stair Climb Power Calculation Result: ________		
6-Minute Walking Test			
Was a walking aid used in any of the above functional tests?	Y / N If yes, which tests?____		
Satisfaction Survey			
SF-36	Sum of responses: _____ Number of responses: _____ **Final score: _____/100** ☐ > 4 responses missing (final score invalid)		

Gift Card given to participant at this date (dd-mmm-yyyy): ______________________

Signature of person completing form: _________________________ Date: ______________________________
Case Report Form V1.0: Jan 22, 2022 Page 3 of 3

Appendix F

Lower Extremity Functional Scale

Lower Extremity Functional Scale:

We are interested in knowing whether you have any difficulty at all with the activities listed below because of your lower limb problem which you are currently seeking attention. Please provide an answer for **each** activity. Circle one number on each line.

Today, do you or would you have any difficulty at all with:

Activities	Extreme difficulty or unable to perform activity	Quite a bit of difficulty	Moderate difficulty	A little bit of difficulty	No difficulty
1. Any of your usual work, housework or school activities	0	1	2	3	4
2. Your usual hobbies, recreational or sporting activities	0	1	2	3	4
3. Getting into or out of the bath	0	1	2	3	4
4. Walking between rooms	0	1	2	3	4
5. Putting on your shoes or socks	0	1	2	3	4
6. Squatting	0	1	2	3	4
7. Lifting an object, like a bag of groceries from the floor	0	1	2	3	4
8. Performing light activities around your home	0	1	2	3	4
9. Performing heavy activities around your home	0	1	2	3	4
10. Getting into or out of a car	0	1	2	3	4
11. Walking 2 blocks	0	1	2	3	4
12. Walking a mile	0	1	2	3	4
13. Going up or down 10 stairs (about 1 flight of stairs)	0	1	2	3	4
14. Standing for 1 hour	0	1	2	3	4
15. Sitting for 1 hour	0	1	2	3	4
16. Running on even ground	0	1	2	3	4
17. Running on uneven ground	0	1	2	3	4
18. Making sharp turns while running fast	0	1	2	3	4
19. Hopping	0	1	2	3	4
20. Rolling over in bed	0	1	2	3	4
Column Totals:					

Score: _____/80

Appendix G

Knee Injury and Osteoarthritis Outcome Score

KOOS KNEE SURVEY

Today's date: _____/______/______ Date of birth: _____/______/______

Name: ____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to perform your usual activities.
Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms
These questions should be answered thinking of your knee symptoms during the **last week**.

S1. Do you have swelling in your knee?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S2. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S3. Does your knee catch or hang up when moving?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S4. Can you straighten your knee fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

S5. Can you bend your knee fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

Stiffness
The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

S6. How severe is your knee joint stiffness after first wakening in the morning?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

S7. How severe is your knee stiffness after sitting, lying or resting **later in the day**?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Pain

P1. How often do you experience knee pain?

Never	Monthly	Weekly	Daily	Always
☐	☐	☐	☐	☐

What amount of knee pain have you experienced the **last week** during the following activities?

P2. Twisting/pivoting on your knee

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P3. Straightening knee fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P4. Bending knee fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P5. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P6. Going up or down stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P7. At night while in bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P8. Sitting or lying

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P9. Standing upright

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A1. Descending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A2. Ascending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A3. Rising from sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A4. Standing

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A5. Bending to floor/pick up an object

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A6. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A7. Getting in/out of car

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A8. Going shopping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A9. Putting on socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A10. Rising from bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A11. Taking off socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A12. Lying in bed (turning over, maintaining knee position)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A13. Getting in/out of bath

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A14. Sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A15. Getting on/off toilet

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A17. Light domestic duties (cooking, dusting, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the **last week** due to your knee.

SP1. Squatting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP2. Running

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP3. Jumping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP4. Twisting/pivoting on your injured knee

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP5. Kneeling

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Quality of Life

Q1. How often are you aware of your knee problem?

Never	Monthly	Weekly	Daily	Constantly
☐	☐	☐	☐	☐

Q2. Have you modified your life style to avoid potentially damaging activities to your knee?

Not at all	Mildly	Moderately	Severely	Totally
☐	☐	☐	☐	☐

Q3. How much are you troubled with lack of confidence in your knee?

Not at all	Mildly	Moderately	Severely	Extremely
☐	☐	☐	☐	☐

Q4. In general, how much difficulty do you have with your knee?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Thank you very much for completing all the questions in this questionnaire.

Appendix H

Inferential Statistics for Smoking Status on Functional Test Measures

Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCT (time in s)?

Table 1.
Tests of Within-Subjects Effects for the SCT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	1763.461	1	1763.461	24.733	<.001	.488	24.733	.998
Time * SmokingStatus	Linear	19.580	1	19.580	.275	.605	.010	.275	.080
Error(Time)	Linear	1853.764	26	71.299					

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SCT (s).**

Table 2.
Levene's Test of Equality of Error Variances[a] for the SCT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbTestPre	Based on Mean	.069	1	26	.794
	Based on Median	.041	1	26	.841
	Based on Median and with adjusted df	.041	1	25.997	.841
	Based on trimmed mean	.053	1	26	.819
StairClimbTestPost	Based on Mean	1.579	1	26	.220
	Based on Median	1.170	1	26	.289
	Based on Median and with adjusted df	1.170	1	25.496	.290
	Based on trimmed mean	1.588	1	26	.219

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SmokingStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCT (s).**

Table 3.
Tests of Between-Subjects Effects for the SCT (s)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	45978.799	1	45978.799	222.517	<.001	.895	222.517	1.000
SmokingStatus	65.459	1	65.459	.317	.578	.012	.317	.084
Error	5372.382	26	206.630					
a. Computed using alpha = .05								

***Note.* This table displays the tests of between-subjects effects for the SCT (s).**

Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)? Table 4.

Tests of Within-Subjects Effects for the SCPT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	173.271	1	173.271	17.661	<.001	.405	17.661	.981
Time * SmokingStatus	Linear	5.869	1	5.869	.598	.446	.022	.598	.116
Error(Time)	Linear	255.087	26	9.811					
a. Computed using alpha = .05									

Note. This table displays the tests of within-subjects effects for the SCPT (s).

Table 5.

Tests of Within-Subjects Effects for The SCPT (W)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	35910.754	1	35910.754	17.149	<.001	.397	17.149	.979
Time * SmokingStatus	Linear	1320.728	1	1320.728	.631	.434	.024	.631	.119
Error(Time)	Linear	54443.591	26	2093.984					
a. Computed using alpha = .05									

Note. This table displays the tests of within-subjects for the SCPT (W)

Table 6.
Levene's Test of Equality of Error Variances[a] for the SCPT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestPre	Based on Mean	.098	1	26	.757
	Based on Median	.040	1	26	.843
	Based on Median and with adjusted df	.040	1	24.443	.844
	Based on trimmed mean	.090	1	26	.767
StairClimbPowerTestPost	Based on Mean	1.270	1	26	.270
	Based on Median	1.091	1	26	.306
	Based on Median and with adjusted df	1.091	1	24.399	.307
	Based on trimmed mean	1.247	1	26	.274

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SmokingStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (s).**

Table 7.
Levene's Test of Equality of Error Variances[a] for the SCPT (W)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestWatts Pre	Based on Mean	.469	1	26	.499
	Based on Median	.320	1	26	.576
	Based on Median and with adjusted df	.320	1	16.088	.579
	Based on trimmed mean	.352	1	26	.558
StairClimbPowerTestWatts Post	Based on Mean	.181	1	26	.674
	Based on Median	.099	1	26	.755
	Based on Median and with adjusted df	.099	1	20.935	.756
	Based on trimmed mean	.144	1	26	.708

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SmokingStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (W).**

Table 8.
Tests of Between-Subjects Effects for the SCPT (s)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7677.968	1	7677.968	261.271	<.001	.909	261.271	1.000
SmokingStatus	15.686	1	15.686	.534	.472	.020	.534	.108
Error	764.062	26	29.387					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (s).**

Table 9.
Tests of Between-Subjects Effects for the SCPT (W)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	2993394.088	1	2993394.088	142.700	<.001	.846	142.700	1.000
SmokingStatus	50806.786	1	50806.786	2.422	.132	.085	2.422	.323
Error	545398.737	26	20976.874					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (W).**

Is there an effect of smoking status (smoker/former smoker versus non-smoker) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

Table 10.
Tests of Within-Subjects Effects for The SMWT (m)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	84437.519	1	84437.519	20.544	<.001	.441	20.544	.992
Time * SmokingStatus	Linear	8373.233	1	8373.233	2.037	.165	.073	2.037	.280
Error(Time)	Linear	106864.481	26	4110.172					

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SMWT (m).**

Table 11.
Levene's Test of Equality of Error Variances[a] for The SMWT (m)

		Levene Statistic	df1	df2	Sig.
SixMinuteWalkTestPre	Based on Mean	.186	1	26	.670
	Based on Median	.243	1	26	.626
	Based on Median and with adjusted df	.243	1	25.787	.626
	Based on trimmed mean	.236	1	26	.631
SixMinuteWalkTestPost	Based on Mean	.969	1	26	.334
	Based on Median	.913	1	26	.348
	Based on Median and with adjusted df	.913	1	25.535	.348
	Based on trimmed mean	.962	1	26	.336

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SmokingStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SMWT (m)**

Table 12.
Tests of Between-Subjects Effects for The SMWT (m)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7461518.421	1	7461518.421	692.135	<.001	.964	692.135	1.000
SmokingStatus	35798.992	1	35798.992	3.321	.080	.113	3.321	.419
Error	280291.508	26	10780.443					

a. Computed using alpha = .05

Note. This table displays the tests of between-subjects effects for the SMWT (m).

Appendix I

Inferential Statistics for Alcohol Consumption Status on Functional Test Measures

Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCT (time in s)?

Table 1.
Tests of Within-Subjects Effects for the SCT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	1507.423	1	1507.423	20.966	<.001	.446	20.966	.993
Time * AlcoholConsumptionStatus	Linear	4.015	1	4.015	.056	.815	.002	.056	.056
Error(Time)	Linear	1869.329	26	71.897					

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SCT (s)**

Table 2.
Levene's Test of Equality of Error Variances[a] for the SCT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbTestPre	Based on Mean	.194	1	26	.664
	Based on Median	.239	1	26	.629
	Based on Median and with adjusted df	.239	1	25.846	.629
	Based on trimmed mean	.211	1	26	.650
StairClimbTestPost	Based on Mean	1.693	1	26	.205
	Based on Median	1.264	1	26	.271
	Based on Median and with adjusted df	1.264	1	25.002	.272
	Based on trimmed mean	1.561	1	26	.223

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + AlcoholConsumptionStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error Variances[a] for the SCT (s).**

Table 3.
Tests of Between-Subjects Effects for the SCT (s)

Transformed Variable: Average								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	37505.308	1	37505.308	181.041	<.001	.874	181.041	1.000
AlcoholConsumptionStatus	51.546	1	51.546	.249	.622	.009	.249	.077
Error	5386.295	26	207.165					
a. Computed using alpha = .05								

***Note.* This table displays the tests of between-subjects effects for the SCT (s).**

Is there an effect of alcohol consumption status (drinker versus non-drinker) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

Table 4.

Tests of Within-Subjects Effects for The SCPT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	122.513	1	122.513	12.307	.002	.321	12.307	.922
Time * AlcoholConsumptionStatus	Linear	2.141	1	2.141	.215	.647	.008	.215	.073
Error(Time)	Linear	258.814	26	9.954					
a. Computed using alpha = .05									

***Note.* This table displays the tests of within-subjects effects for the SCPT (s).**

Table 5.

Tests of Within-Subjects Effects for the SCPT (W)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	28076.165	1	28076.165	13.091	.001	.335	13.091	.936
Time * AlcoholConsumptionStatus	Linear	1.500	1	1.500	.001	.979	.000	.001	.050

Error(Time)	Linear	55762.819	26	2144.724

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SCPT (W).**

Table 6.

Levene's Test of Equality of Error Variances[a] for The SCPT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestPre	Based on Mean	.161	1	26	.691
	Based on Median	.192	1	26	.665
	Based on Median and with adjusted df	.192	1	25.888	.665
	Based on trimmed mean	.165	1	26	.688
StairClimbPowerTestPost	Based on Mean	.442	1	26	.512
	Based on Median	.541	1	26	.469
	Based on Median and with adjusted df	.541	1	25.689	.469
	Based on trimmed mean	.416	1	26	.524

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + AlcoholConsumptionStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (s).**

Table 7.

Levene's Test of Equality of Error Variances[a] for The SCPT (W)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestWattsPre	Based on Mean	1.678	1	26	.207
	Based on Median	.842	1	26	.367
	Based on Median and with adjusted df	.842	1	11.328	.378
	Based on trimmed mean	1.048	1	26	.316
StairClimbPowerTestWattsPost	Based on Mean	1.818	1	26	.189
	Based on Median	.896	1	26	.353
	Based on Median and with adjusted df	.896	1	13.916	.360
	Based on trimmed mean	1.485	1	26	.234

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + AlcoholConsumptionStatus
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (W).**

Table 8.
Tests of Between-Subjects Effects for the SCPT (s)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	6195.739	1	6195.739	210.133	<.001	.890	210.133	1.000
AlcoholConsumptionStatus	13.143	1	13.143	.446	.510	.017	.446	.099
Error	766.604	26	29.485					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (s).**

Table 9.
Tests of Between-Subjects Effects for the SCPT (W)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	2596440.565	1	2596440.565	116.524	<.001	.818	116.524	1.000
AlcoholConsumptionStatus	16862.649	1	16862.649	.757	.392	.028	.757	.134
Error	579342.874	26	22282.418					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (W).**

Table 10.
Tests of Within-Subjects Effects for the SMWT (m)

Measure: MEASURE_1

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	76377.857	1	76377.857	17.788	<.001	.406	17.788	.982
Time * AlcoholConsumptionStatus	Linear	3600.714	1	3600.714	.839	.368	.031	.839	.143

Error(Time)	Linear	111637.000	26	4293.731

a. Computed using alpha = .05

***Note.* This table displays the tests of within-subjects effects for the SMWT (m).**

Table 11.

Levene's Test of Equality of Error Variances[a] for The SMWT (m)

		Levene Statistic	df1	df2	Sig.
SixMinuteWalkTestPre	Based on Mean	.182	1	26	.673
	Based on Median	.168	1	26	.685
	Based on Median and with adjusted df	.168	1	25.824	.685
	Based on trimmed mean	.181	1	26	.674
SixMinuteWalkTestPost	Based on Mean	.074	1	26	.788
	Based on Median	.077	1	26	.784
	Based on Median and with adjusted df	.077	1	24.224	.784
	Based on trimmed mean	.073	1	26	.789

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + AlcoholConsumptionStatus

Within Subjects Design: Time

***Note.* This table displays Levene's test of equality of error variances[a] for the SMWT (m).**

Table 12.

Tests of Between-Subjects Effects for The SMWT (m)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	6614177.857	1	6614177.857	544.591	<.001	.954	544.591	1.000
AlcoholConsumptionStatus	315.000	1	315.000	.026	.873	.001	.026	.053
Error	315775.500	26	12145.212					

a. Computed using alpha = .05

***Note.* This table displays the tests of between-subjects effects for the SMWT (m).**

Appendix J

Inferential Statistics for Comorbidities Present on Functional Test Measures

Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCT (time in s)?

Table 1.
Tests of Within-Subjects Effects for the SCT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	1876.558	1	1876.558	27.710	<.001	.516	27.710	.999
Time * ComorbiditiesPresent	Linear	112.603	1	112.603	1.663	.209	.060	1.663	.237
Error(Time)	Linear	1760.742	26	67.721					

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SCT (s).**

Table 2.
Levene's Test of Equality of Error Variances[a] for the SCT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbTestPre	Based on Mean	.004	1	26	.951
	Based on Median	.000	1	26	.986
	Based on Median and with adjusted df	.000	1	25.410	.986
	Based on trimmed mean	.003	1	26	.953
StairClimbTestPost	Based on Mean	.900	1	26	.351
	Based on Median	.791	1	26	.382
	Based on Median and with adjusted df	.791	1	24.367	.382
	Based on trimmed mean	.828	1	26	.371

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ComorbiditiesPresent
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCT (s).**

Table 3.
Tests of Between-Subjects Effects for the SCT (s)

Transformed Variable: Average								
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	46292.382	1	46292.382	226.853	<.001	.897	226.853	1.000
ComorbiditiesPresent	132.185	1	132.185	.648	.428	.024	.648	.121
Error	5305.656	26	204.064					
a. Computed using alpha = .05								

***Note.* This table displays the tests of between-subjects effects for the SCT (s).**

Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SCPT (time in s and power in W)?

Table 4.

Tests of Within-Subjects Effects for The SCPT (s)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	177.479	1	177.479	18.388	<.001	.414	18.388	.985
Time * ComorbiditiesPresent	Linear	10.011	1	10.011	1.037	.318	.038	1.037	.165
Error(Time)	Linear	250.944	26	9.652					
a. Computed using alpha = .05									

***Note.* This table displays the tests of within-subjects effects for the SCPT (s).**

Table 5.

Tests of Within-Subjects Effects for The SCPT (W)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	36372.665	1	36372.665	17.513	<.001	.402	17.513	.981
Time * ComorbiditiesPresent	Linear	1764.938	1	1764.938	.850	.365	.032	.850	.144

Error(Time)	Linear	53999.381	26	2076.899
a. Computed using alpha = .05				

Note. **This table displays the tests of within-subjects effects for the SCPT (W).**

Table 6.

Levene's Test of Equality of Error Variances[a] for The SCPT (s)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestPre	Based on Mean	.351	1	26	.559
	Based on Median	.382	1	26	.542
	Based on Median and with adjusted df	.382	1	25.641	.542
	Based on trimmed mean	.325	1	26	.573
StairClimbPowerTestPost	Based on Mean	2.500	1	26	.126
	Based on Median	1.017	1	26	.323
	Based on Median and with adjusted df	1.017	1	18.041	.327
	Based on trimmed mean	2.119	1	26	.157

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ComorbiditiesPresent
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (s).**

Table 7.

Levene's Test of Equality of Error Variances[a] for The SCPT (W)

		Levene Statistic	df1	df2	Sig.
StairClimbPowerTestWatts Pre	Based on Mean	.891	1	26	.354
	Based on Median	.812	1	26	.376
	Based on Median and with adjusted df	.812	1	21.284	.378
	Based on trimmed mean	.759	1	26	.392
StairClimbPowerTestWatts Post	Based on Mean	2.169	1	26	.153
	Based on Median	1.058	1	26	.313
	Based on Median and with adjusted df	1.058	1	18.321	.317
	Based on trimmed mean	1.479	1	26	.235

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ComorbiditiesPresent
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SCPT (W).**

Table 8.
Tests of Between-Subjects Effects for the SCPT (s)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7632.721	1	7632.721	257.006	<.001	.908	257.006	1.000
ComorbiditiesPresent	7.584	1	7.584	.255	.618	.010	.255	.078
Error	772.163	26	29.699					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (s).**

Table 9.
Tests of Between-Subjects Effects for the SCPT (W)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	2791129.661	1	2791129.661	122.276	<.001	.825	122.276	1.000
ComorbiditiesPresent	2719.424	1	2719.424	.119	.733	.005	.119	.063
Error	593486.099	26	22826.388					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SCPT (W).**

Is there an effect of comorbidities present (≤ 1 versus ≥ 2) on pre- versus post-surgical functional performance for the SMWT (distance in m)?

Table 10.
Tests of Within-Subjects Effects for the SMWT (m)

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	81465.552	1	81465.552	19.135	<.001	.424	19.135	.988

Time * ComorbiditiesPresent	Linear	4546.409	1	4546.409	1.068	.311	.039	1.068	.169
Error(Time)	Linear	110691.305	26	4257.358					

a. Computed using alpha = .05

Note. **This table displays the tests of within-subjects effects for the SMWT (m).**

Table 11.

Levene's Test of Equality of Error Variances[a] for The SMWT (m)

		Levene Statistic	df1	df2	Sig.
SixMinuteWalkTestPre	Based on Mean	.091	1	26	.765
	Based on Median	.173	1	26	.681
	Based on Median and with adjusted df	.173	1	25.728	.681
	Based on trimmed mean	.127	1	26	.724
SixMinuteWalkTestPost	Based on Mean	.628	1	26	.435
	Based on Median	1.012	1	26	.324
	Based on Median and with adjusted df	1.012	1	24.912	.324
	Based on trimmed mean	.774	1	26	.387

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ComorbiditiesPresent
Within Subjects Design: Time

Note. **This table displays Levene's test of equality of error variances[a] for the SMWT (m).**

Table 12.

Tests of Between-Subjects Effects for the SMWT (m)

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7412271.126	1	7412271.126	733.970	<.001	.966	733.970	1.000
ComorbiditiesPresent	53519.698	1	53519.698	5.300	.030	.169	5.300	.601
Error	262570.802	26	10098.877					

a. Computed using alpha = .05

Note. **This table displays the tests of between-subjects effects for the SMWT (m).**

Appendix K

Standard Operating Procedures for Functional Tests

Stair Climb Power Test (SCPT)

Measures functional strength, dynamic balance & agility[1]

Phases

Pre-op
Post-acute
Active living

ICF

Pre-op
Post-acute
Active Living

Time

~ 2 mins to complete and score[1,2]

Equipment

Stairs (8–14 steps) with handrails, timer/stopwatch
Where possible, the 9-step stair test with 20cm (8") step height (range 16-20 cm) and handrail are recommended[2]

Instructions

- Place cones at the top and bottom of stairs indicating start and finish points
- Place chairs at the top and bottom of stairs for rest if required by participants
- Ensure handrails are available if needed for participants
- Begin with the participant at the bottom of the stairwell
- On the command "go" instruct the participant to ascend the stairs as fast/safe as possible
- Record time taken to ascend the stairs
- Record the participants weight in (kg) and multiply by gravity ($9.8m/s^2$)
- After initial calculation, multiply by height of stairs in meters (ex. 2.59m)
- After second calculation divide by time taken to complete the test
- Average power (watts) will be result for the SCPT
- Factors such as time taken to complete testing (seconds) and weight of participants determine average power (W)

Appendix L

Consort Flow Chart