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MONIKA METS

Effect of a preoperative home exercise program on motor function in women with severe knee osteoarthritis scheduled for total arthroplasty

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Institute of Sport Sciences and Physiotherapy, Faculty of Medicine, University of Tartu, Tartu, Estonia

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“Take care of your body. It’s the only place you have to live.”
Jim Rohn

This thesis is dedicated to the memory of my beloved father, whose belief in me remains a source of strength. Thank you for cheering me on, even from afar.

To my dear mother – your dedication to lifelong learning while raising a family has been a true inspiration, giving me the courage to pursue my own academic path.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following peer-reviewed publications, which are cited in the text using Roman numbers:

I. Rätsepsoo, M., Gapeyeva, H., Sokk, J., Ereline, J., Haviko, T., & Pääsuke, M. (2013). Leg extensor muscle strength, postural stability, and fear of falling after a 2-month home exercise program in women with severe knee joint osteoarthritis. *Medicina (Kaunas), 49*(8), 54. https://doi.org/10.3390/medicina49080054

II. *Mets, M., Tootsi, P., Sokk, J., Ereline, J., Haviko, T., Pääsuke, M., & Gapeyeva, H. (2022). Thigh muscle activation after a home exercise program in knee osteoarthritis patients. *Physical & Occupational Therapy In Geriatrics, 40*(4), 337–359. https://doi.org/10.1080/02703181.2022.2036295

III. Mets, M., Sokk, J., Ereline, J., Pääsuke, M., Haviko, T., & Gapeyeva, H. (2025). The influence of an eight-week home exercise program on spatio-temporal and kinetic characteristics of gait and knee function in women with severe knee osteoarthritis scheduled for arthroplasty. *Medicina, 61*(5), 774. https://doi.org/10.3390/medicina61050774

*Name changed due to marriage (from Monika Rätsepsoo to Monika Mets).

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In Papers I, II, and III, Monika Mets contributed to data collection and analysis and held primary responsibility for writing the original manuscripts.

ABBREVATIONS

AROM flex	Active knee flexion range of motion
AROM ext	Active knee extension range of motion
BMI	Body mass index
CON	Control
COP	Centre of pressure
EMG	Electromyography
FTSST	Five Times Sit-to-Stand test
GRF	Ground reaction force
HEP	Home exercise program
KEM	Knee extension moment
KOA	Knee osteoarthritis
MFES	Modified Falls Efficiency Scale
MVC	Maximal voluntary contraction
Pre-HEP	Before the home exercise program
Post-HEP	After the home exercise program
PT	Peak torque
PT-to-BM	Peak torque-to-body mass ratio
RMS	Root mean square
RPTD	Relative peak torque development
TKA	Total knee arthroplasty
TUG	Timed Up & Go test
VAS	Visual Analogue Scale
WOMAC	The Western Ontario and McMaster Universities Arthritis Index

1. INTRODUCTION

Knee osteoarthritis (KOA) is a prevalent degenerative joint disease affecting adults, with its incidence rising as the population ages and obesity rates increase. KOA manifests through various symptoms, including joint pain, swelling and stiffness, and other functional limitations that significantly impair patients' quality of life (Lespasio et al., 2017; Kiritbhai et al., 2023). Women are disproportionately more affected compared to men and experience more symptoms related to KOA, possibly due to genetic factors (Tonelli et al., 2011; Ma et al., 2022). Women are also more likely to undergo total knee arthroplasty (TKA) (Klug et al., 2021).

Surgical interventions, such as TKA, are typically reserved for patients who have significant knee function impairment related to end-stage KOA (Zeng et al., 2021). This typically applies to individuals with grade 3 or 4 KOA according to the Kellgren and Lawrence radiographic grading system (Kellgren & Lawrence, 1957). The prevalence of KOA rises, so does the demand for TKA (Yang et al., 2023). As there is a high cost and significant burden associated with surgical interventions (Ackerman et al., 2019), it is essential to explore strategies that optimize outcomes. Treatment options before surgery include pharmacologic and non-pharmacologic approaches. Among these, exercise therapy is one of the primary interventions for alleviating symptoms and improving function in KOA patients (Hurley, 2003; Bennel & Hinman, 2011).

Regular exercising is recommended for individuals with KOA at all stages of the disease (Bennell & Hinman, 2011). Exercise interventions should target the primary motor function and functional mobility impairments related to KOA. Compared to peers without KOA, individuals with KOA often have difficulties performing functional tasks, experience pain and demonstrate reduced lower limb muscle strength and knee range of motion, and changes in movement patterns and balance (Hoops et al., 2012; Kiritbhai et al., 2023). Engaging in exercise therapy can relieve symptoms and improve these functions. Various exercise interventions, including muscle strengthening, balance training, and stretching exercises, have shown positive outcomes. These interventions are essential for short-term results and as part of prehabilitation to support postoperative recovery (Swank et al., 2011). Existing studies on exercise therapy for patients with KOA have primarily focused on less severe stages of KOA or postoperative interventions. There is a noticeable gap in research examining the impact of exercise therapy – particularly preoperative home exercise therapy – in patients with severe KOA.

While exercises are performed more persistently under the supervision of physiotherapists, the availability of regular outpatient visits or related costs often limits the implementation of supervised exercise therapy (O'Reilly et al., 1999; Brophy & Fillingham, 2022). It is essential to prioritise interventions that are safe, accessible, and affordable over those with lower feasibility and higher costs. Additionally, since supervision can also be provided remotely (RACGP, 2018), a home exercise program (HEP) offers a simple and accessible alternative to outpatient treatment. Preoperative HEPs are being recognised for their potential beneficial effect on functional outcomes in patients with severe KOA (Thomas et al., 2002; Deyle et al., 2005; Topp et al., 2009; Silva et al., 2018). However, there is a lack of information clarifying the specific effects of these programs, particularly in patients with severe KOA who are undergoing total knee arthroplasty (TKA). Therefore, this study aimed to determine the effects of preoperative HEP on motor function, functional mobility, and perceived health status in women with severe KOA scheduled for TKA.

2. REVIEW OF LITERATURE

2.1. Knee osteoarthritis

The World Health Organization and The United Nations have declared 2021–2030 as the Decade of Healthy Ageing. This emphasizes the importance of addressing diseases like osteoarthritis, which considerably impact functional ability and quality of life in older adults. In 2020, an estimated 7.6% of the world's population – approximately 595 million people – were affected by osteoarthritis, and its prevalence continues to rise (GBD 2021 Osteoarthritis Collaborators, 2023). Around 344 million individuals have moderate to severe osteoarthritis and could benefit from rehabilitation (Cieza et al., 2020). With the population aging and the obesity rates increasing, KOA has become a common cause of disability accounting for 4.9% of all diseases worldwide (Cross et al, 2014; Yang et al., 2023). The global age-standardized prevalence of KOA in 2019 was 4376 per 100,000, showing a 7.5% increase in the last two decades and approximately 29.5 million new incidents of KOA were diagnosed globally, with the global prevalence reaching 364 million people. Incidence of KOA increases with age and most people are diagnosed around 45–69 years of age (Yang et al., 2023). By 2050, the prevalence of KOA is expected to increase 74.9%, and it is estimated to represent over 80% of all osteoarthritis burden (GBD 2021 Osteoarthritis Collaborators, 2023).

In general, osteoarthritis is classified into two types: primary osteoarthritis, which develops in healthy joints without known cause, and secondary osteoarthritis, which occurs due to known causal factors like trauma (Taruc-Uy & Lynch, 2013). Primary KOA typically develops gradually over the span of 10 to 15 years, affecting the medial, lateral, and patellofemoral compartments of the knee joint (Steinhoff & Bugbee, 2016), leading to pain, disability, and impairment in daily activities (Chen et al., 2017; Yunus et al., 2020). The development of primary KOA is not fully understood, though it is recognized as a multifactorial condition. Modifiable and unmodifiable factors such as obesity, age, immune or inflammatory diseases, genetics, and musculoskeletal issues contribute to the onset of the disease (Lespasio et al., 2017; Yang et al., 2023). Regardless of the underlying cause, the entire knee joint is affected, including the joint cartilage, subchondral bone, synovial tissue, ligaments and meniscus. KOA can be characterized by joint cartilage degeneration, formation of osteophytes, subchondral sclerosis and synovial hyperplasia (Chen et al., 2017). The main clinical symptoms include joint pain, swelling, instability and stiffness (RACGP, 2018; Kiritbhai et al., 2023).

Typically, symptoms worsen as the condition progresses (Steencamp et al., 2022), making KOA a leading cause of functional impairment in individuals aged 60 and above and ranking it 11th among 291 global causes of disability (Cross et al., 2014; Primorac et al., 2020). It profoundly affects patients' functionality and ability to perform daily activities (Kiritbhai et al., 2023). Individuals with

KOA often have difficulties with walking, climbing stairs, sit-to-stand tasks, and engaging in active daily living activities. They even refrain from valued activities, including walking workouts, and are more sedentary than those without KOA (Lespasio et al., 2017; Katz et al., 2021). Walking ability, among other things, is one of the predicting factors of general health and safety in older adults (Pirker & Katzenschlager, 2017). Difficulties in everyday activities can also lower the quality of life and perceived health status in people with KOA (Fang et al., 2015; Lespasio et al., 2017; RACGP, 2018).

In addition to age, the risk of developing KOA is also influenced by gender. Epidemiological data shows that KOA is significantly more prevalent in women, with a women-to-men ratio of approximately 1.47 (Brophy & Fillingham, 2022; Yang et al., 2023). Gender-based hormonal influences and anatomical differences such as narrower femurs, thinner patellae, larger quadriceps angles, and variations in tibial condyle size affect knee joint kinematics and contribute to women being more predisposed to developing KOA and may explain the higher prevalence in women. Gender differences in KOA presentation and treatment also exist. Women experience greater symptoms and seek treatment in more advanced stages of KOA than men (Hame & Alexander, 2013; Kiritbhai et al., 2023).

KOA is diagnosed via medical history, physical examination and X-rays. X-rays may reveal narrowing of the joint space, changes in the bone, and formation of osteophytes (Lespasio et al., 2017). The severity of KOA is assessed using the Kellgren and Lawrence radiographic grading scale, which ranges from 0 to 4, with grade 0 indicating no signs of osteoarthritis and grade 4 reflecting severe osteoarthritis (Kellgren & Lawrence, 1957). TKA is the gold standard treatment for individuals with advanced symptoms and structural changes (Katz et al., 2021; Postler et al., 2023; WHO, 2023), in most cases corresponding to grade 3 and 4. In both grades, TKA has shown similar positive outcomes (Dowsey et al., 2012; Goh et al., 2023). In 2018, 170 494 primary TKA procedures were performed in Germany, 2/3 of which were performed on women. By 2050, this number is expected to increase by approximately 43% to 225 957 operations (Klug et al., 2021).

While pain management and surgical intervention are standard treatments for severe osteoarthritis, there is a growing clinical interest in exploring alternative therapeutic strategies, particularly exercise therapy in various settings, which may help alleviate KOA symptoms and motor dysfunction, while also preparing patients for the physical demands of TKA (Swank et al., 2011; Chen et al., 2017).

2.2. Motor function and functional mobility impairment in knee osteoarthritis

KOA is associated with various symptoms and functional limitations caused by pathological changes in joint structures and surrounding muscles, leading to impaired daily activities (Katz et al., 2021). The primary motor impairments include constant or intermittent joint pain, stiffness and swelling, decreased lower limb muscle strength and joint motion, and altered movement patterns (e.g. during gait) (Kiritbhai et al., 2023). These symptoms tend to intensify as the disease advances, resulting in a more pronounced presentation in severe stages of KOA (Gelber, 2024). This is particularly evident in women, who often report higher pain levels, lower perceived functionality, and greater difficulty with specific functional tasks prior to TKA compared to men (Tonelli et al., 2011; Kiritbhai et al., 2023). Joint pain is the most prevalent dysfunction of osteo-arthritis, with over 66% of patients experiencing constant pain (Cross et al., 2014). In KOA, joint pain typically worsens with weight-bearing activities and improves with rest, but in advanced stages, it may become constant and persist even during rest (WHO, 2023; Gelber, 2024). Pain during movement can also reduce the quality of life as osteoarthritis patients tend to avoid movements and activities that cause or increase pain. This can reduce their physical activity and influence other health-related issues, such as cardiovascular diseases, obesity and diabetes (WHO, 2023). Due to this, most interventions are aimed at pain relief (Kolasinski et al., 2020; Brophy & Fillingham, 2022).

In addition to pain, joint stiffness and limited range of motion are common in KOA (Brophy & Fillingham, 2022) and get worse with more severe radiographic lesions (Zhou et al., 2023). Joint stiffness can serve as a compensatory mecha-nism to manage joint instability, especially in the advanced stages of KOA (Zeni & Higginson, 2009). These dysfunctions further elevate the risk of other functio-nal limitations in this patient group. For instance, individuals with KOA take longer to perform functional tasks than peers without KOA. This is reflected in the results of functional test, such as the Five Times Sit-to-Stand test (FTSST) and Timed Up & Go test (TUG) (Kiritbhai et al., 2023; Yokota et al., 2023), indicating impaired functional mobility and lower limb muscle strength. These functional measures can also indicate other impairments, such as balance deficits and risk of falling. For instance, FTSST time of 8.8 s or more is associated with increased risk of falling in older adults (Amano & Tamari, 2022). Over 25% of older adults experience falls each year, commonly associated with declined mobility, gait stability, and balance. These falls can result in severe injury and fear of falling, limiting daily activities and reducing the quality of life (Dhar et al., 2022; Camp et al., 2024; Colón-Emeric et al., 2024;). Individuals with lower extremity osteoarthritis have up to 2.5 times greater risk of falling compared to peers without osteoarthritis (Hoops et al., 2012). In KOA, postural stability keeps declining as the disease progresses and is associated with functional impairments including reduced muscle strength and compromised knee joint proprioception (Hassan et al., 2001; Tarigan et al., 2009).

Alterations in postural and movement patterns may also be present. Patients with KOA frequently offload the affected limb while standing (Nagymate et al., 2016), likely as a compensatory strategy to reduce pain, discomfort, or instability. Similar compensatory alterations are evident during gait (Hoops et al., 2012). Among non-neurological causes of gait disorders, KOA is particularly prevalent (Chambers & Sutherland, 2002; Pirker & Katzenschlager, 2017). Patients with KOA often exhibit changes in spatiotemporal parameters, kinematics, and kinetics as compensatory strategies to reduce pain and joint loading (Fukaya et al., 2019). As KOA advances, walking speed gradually decreases, accompanied by reductions in knee flexion angles and extensor moments during the stance phase (Astephen et al., 2008; Ogaya et al., 2017). However, joint moments and ground reaction forces are generally less studied compared to spatiotemporal parameter, (Roberts et al., 2017) despite their known associations with KOA-related functional limitations (Fukaya et al. 2019). In addition, these altered gait patterns can be different in women and men. Women with KOA exhibit disease-related differences in knee biomechanics, such as lower knee moments, compared to men, indicating that KOA may be the cause of the gender-dependent biomechanical alterations during gait or vice versa (Ogaya et al., 2017; Yamagata et al., 2025).

In addition to noticeable changes in movement patterns, individuals with KOA exhibit altered movement strategies and muscle activation. These changes are particularly evident during gait and sit-to-stand tasks, where, for example, gait is characterized by decreased knee extensor activity and increased knee flexor activity, while sit-to-stand movements show greater antagonist co-activation (Davidson et al., 2013; Sharma et al., 2017). Increased hamstring co-contraction is associated with modifying the movement to avoid or reduce pain, maintain better function, and compensate for functional limitations such as decreased muscle strength (Bouchouras et al., 2015). The latter correlates with knee pain (Kiritbhai et al., 2023), which explains why knee extensor muscle strength decreases in severe KOA even when muscle mass remains unchanged (Wada et al., 2019). These muscle activation changes and decreased muscle strength are correlated with disease progression and can be especially prevalent in severe KOA (Christiansen & Stevens-Lapsley, 2010; Davidson et al., 2013; de Zwart et al., 2018). Compared to peers without KOA, individuals with KOA demonstrate lower muscle strength and increased thigh muscle co-activation during weight-bearing activities, whereas women demonstrate greater muscle weakness and higher levels of co-activation than men. This increased co-activation and muscle weakness is considered a compensatory strategy to stabilize the joint and maintain functional performance. However, it may cause excessive loads on the knee joint structures, potentially accelerating joint degeneration and contributing to the higher incidence and faster progression of KOA in women (Smith et al., 2020).

Thus, gait and other functional mobility alterations could be present due to weakness of the lower limb muscles. The knee extensor muscles are often most affected by KOA, and reduced knee extensor strength is considered a risk factor for KOA-related functional impairments and disease progression (Jegu et al., 2014; Patterson et al., 2023). Consequently, many strengthening interventions have focused primarily or exclusively on the quadriceps muscle group (Henrotin et al., 2012), while a more comprehensive understanding of functional limitations related to KOA and TKA might be achieved by evaluating lower limb strength using a closed-chain method instead of open-chain assessment of the knee extensor strength (Rossi et al., 2007).

It is also important to note that individuals with unilateral KOA often exhibit inter-limb asymmetries in muscle strength, proprioception, gait biomechanics, and postural stability. These variables are closely interrelated and worsen as the disease progresses (Zeng et al., 2022; Wang et al., 2023). Additionally, unilateral pain is also linked to these asymmetries (Creaby et al., 2012) and women have been identified to be at higher risk of developing gait-related asymmetries (Li et al., 2024). These aspects should be considered in prevention and rehabilitation of patients with KOA (Zeng et al., 2022).

2.3. Evaluating motor function and functional mobility in knee osteoarthritis

Considering the impairments and symptoms associated with KOA and their correlation with disease progression (Gelber, 2024), patients with KOA should be regularly monitored. When evaluating the function and health status of individuals with KOA, several factors should be considered, including pain levels, limitations in daily activities and participation, functional ability (e.g. walking, sit-to-stand transitions, postural stability), risk of falling, and overall quality of life (RACGP, 2018). It is important to use a multidimensional approach and consider perceived outcomes also rather than solely relying on objective measures of physical function (Yokota et al., 2023). As objective performance tests and subjective self-reported function measures have a weak association, adding both in the assessment of functional status of osteoarthritis patients is essential (Selzer et al., 2022). Therefore, patient self-reported measures of perceived health status should be included in planning treatments and evaluations (Hussain et al., 2024). Regular evaluations help to determine the effect of treatments and interventions (RACGP, 2018).

Various clinical assessment tools are available to evaluate functional status and patient-reported outcomes in KOA patients, which can also be used in clinical research. Self-reported measures like the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Visual Analogue Scale (VAS) score for pain are essential for assessing perceived symptoms and health status. In parallel, objective measurements such as timed functional tasks (e.g. FTSST and TUG), gait parameters (e.g. cadence, walking speed, and knee joint moments), and motor function measures (e.g. goniometry, dynamometry, electromyography) offer valuable insights into performing daily activities and possible function impairments (Sparkes et al., 2019; Hussain et al., 2024). Instrumented assessment tools are widely used in clinical and research settings (Cimolin & Galli, 2014). For example, three-dimensional gait analysis − a gold standard for assessing spatiotemporal, kinematic, and kinetic gait parameters− is particularly valuable for individuals with KOA (Fukaya et al., 2019), helping to assess disease severity, symptoms, and functional capacity (Li et al., 2022), as well as evaluating the effectiveness of rehabilitation programs (Cimolin & Galli, 2014), while also providing objective data to guide both surgical and rehabilitation decisions (Chambers & Sutherland, 2002).

Previous studies show that individuals with KOA have impairments in both knee extensors and flexors compared to controls (Adegoke et al., 2007), with the extensor muscles being often more affected (Jegu et al., 2014). This muscle dysfunction can alter everyday activities, such as walking. The gait cycle has two alternating phases: stance and swing. The stance phase comprises approximately 60% of the gait cycle and includes the sub-phases of initial contact, loading response, mid-stance, terminal stance, and pre-swing (Cicirelli et al., 2022). The stance phase of gait is affected in individuals with KOA, primarily as a pain avoidance strategy due to increased discomfort during weight-bearing (Fukaya et al., 2019). Leg extensor muscles play a crucial role during the stance phase of gait, particularly in the loading response (Kirtley, 2006). During this early stance phase, the main muscles working are the knee extensors, including rectus femoris, vastus medialis, vastus intermedius, and vastus lateralis, as well as the knee flexors, including biceps femoris, semitendinosus, and semimembranosus (Sylvester et al., 2021). The extensor group is primarily responsible for generating the knee extension moment during this phase (Ogaya et al., 2017). Therefore, targeted assessment and intervention for these muscle groups, particularly the leg extensors, are essential.

2.4. Home exercise programs in prehabilitation of knee osteoarthritis

The primary treatment goals for KOA are to manage symptoms and enhance quality of life (Thompson et al., 2021). Among non-surgical options, exercise therapy is a safe approach to improve function and reduce disability in chronic diseases, including osteoarthritis (Pasanen et al., 2017). Unlike pharmacological treatments, exercise offers a low-risk, non-invasive approach that improves performance and function making structured physical activity a safe and effective rehabilitation option for osteoarthritis patients (Henrotin et al., 2012). As one of the main conservative interventions in KOA management, exercise therapy is beneficial regardless of the stage or severity of the disease and can be effective both pre- and post-TKA (Bennell & Hinman, 2011; RACGP, 2018; Raposo et al., 2021). It addresses the physical impairments caused by KOA and prompts overall health. Physiological adaptations such as increased muscle strength, improved neuromuscular control, greater joint stability, enhanced range of motion, better mobility and cardiovascular fitness are commonly observed with regular exercising (Henrotin et al., 2012; WHO, 2023). For older adults with KOA, rehabilitation strategies that facilitate smooth transitions (e.g. from sitting to standing) may enhance social participation and improve health-related quality of life (Yokota et al., 2023).

Evidence suggests that aerobic and resistance-based exercises are equally effective in relieving pain and improving daily functioning in individuals with osteoarthritis (Henrotin et al., 2012). Strengthening thigh muscles is particularly effective (Swank et al., 2011; Al-Johani et al., 2014; Fransen et al., 2015). Exercise programs are recommended to also include stretching exercises, neuromuscular and balance training (Chang et al., 2012; Kolasinski et al., 2020; Raposo et al., 2021). Strengthening exercises, alone or combined with balance and functional training, reduce knee pain and increase lower limb muscle strength, improve balance, quality of life, and perceived health in KOA patients, with sustained benefits lasting up to 6 months (Fransen et al., 2015, Brosseau et al., 2017). Exercise programs that aim to improve lower limb muscle strength and balance also prevent falls, which are a significant health risk for older adults with osteoarthritis (Hoops et al., 2012¸Colón-Emeric et al., 2024). Neuromuscular training may further improve walking (Brophy & Fillingham, 2022). Resistance exercises are also vital for preparing KOA patients for TKA (Swank et al., 2011).

In general, 8- to 12-week exercise programs show good adherence in KOA patients (Whitfield & Tomlinson, 2025). However, it has been found that beyond 8 weeks, the dose-response relationship begins to plateau, and adherence tends to decline, especially with longer training periods and higher intensities (Lee et al., 2018; Whitfield & Tomlinson, 2025). In advanced stages of KOA, lower-intensity exercise programs have shown better results compared to early stages (Whitfield & Tomlinson, 2025), suggesting that exercise interventions should be tailored to the stage of disease progression. Since preoperative functional status has been found to predict postoperative performance in patients with severe KOA (Mizner et al., 2005), improving the health and functional status before surgery can enhance recovery and reduces complications (Long et al., 2005; Kubo et al., 2020; Ohno et al., 2022). Therefore, preoperative exercise therapy is recommended (Regan et al., 2013) and even 3- to 8-week exercise programs focusing on lower limb muscle strength can improve physical activity, knee joint motion, and pain before TKA (Swank et al., 2011; Ohno et al., 2022).

While postoperative exercise programs are well-studied, more research is needed on different preoperative exercise approaches, especially for patients with severe KOA (Kuru Çolak et al., 2017). Preoperative exercise programs have also been found to be easily transferable to the home environment (Swank et al., 2011). Patients with KOA can benefit from various exercises, with no clear advantage of supervised over unsupervised (Brophy & Fillingham, 2022). While supervised exercise programs tend to offer superior outcomes, home-based exercises can be a feasible and accessible alternative when supervision is not available (Mapinduzi et al., 2025). Although exercises are usually performed more persistently under supervision, supervised programs can be costly and less accessible (O'Reilly et al., 1999; Brophy & Fillingham, 2022). Although the health economics of exercise interventions remain to be fully investigated (Whitfield & Tomlinson, 2025), HEPs provide an accessible and safe alternative when financial or clinical resources are limited (Si et al., 2023), which is an important factor for ensuring adherence (Loew et al., 2016; Kolasinski et al., 2020). Accessible and regular exercise is key (Brosseau et al., 2017), and guidance from a physiotherapist can be provided in person or remotely (RACGP, 2018). HEPs are user-friendly, quick, and affordable (Thomas et al., 2002; Chen et al., 2019), showing similar benefits to supervised outpatient exercise therapy (Kuru Çolak et al., 2017; Kolasinski et al., 2020). Preoperative HEPs have shown potential to improve mobility and muscle strength and reduce pain in individuals with severe KOA (Thomas et al., 2002; Deyle et al., 2005; Topp et al., 2009; Silva et al., 2018). They also improve perceived health status and quality of life before TKA (Si et al., 2023) and may enhance postoperative recovery or even delay the need for surgery (Aytekin et al., 2019). However, despite these promising results, the effectiveness of preoperative HEPs is less understood and remains understudied compared to postoperative rehabilitation and treatments for earlier stages of the disease.

2.5. Rationale for the study

KOA is a leading cause of pain and functional impairment, particularly among older women, who are more affected in terms of prevalence, disease progression and symptom severity. Management strategies aim to preserve and enhance functional capacity and quality of life, with surgical intervention often necessary in the advanced stages. While the benefits of exercise therapy for individuals with mild to moderate osteoarthritis are well established, the role of preoperative exercise interventions in patients with severe KOA remains under-investigated, despite the increasing interest in prehabilitation. As preoperative HEPs have the potential to enhance functional outcomes in individuals with severe KOA prior to TKA, this study aimed to address the gap of knowledge by evaluating the effect of a preoperative HEP on both objective and subjective measures of motor function and mobility in individuals with severe KOA scheduled for TKA. Additionally, it sought to clarify the potential of the HEP to alleviate motor and functional deficits associated with KOA, with a particular focus on women.

3. AIMS OF THE STUDY

The aim of this study was to determine the effect of an 8-week preoperative HEP on motor function, functional mobility, and perceived health status in women with severe KOA scheduled for TKA, and to compare the results with age- and gender-matched controls without KOA.

According to the aim of the present study, the specific objectives were:

1. To assess the changes in postural stability and perceived fear of falling after an 8-week preoperative HEP in women with severe KOA.
2. To evaluate changes in spatiotemporal and kinetic gait characteristics during the stance phase after an 8-week preoperative HEP in women with severe KOA.
3. To investigate the changes in the bioelectrical activity of thigh muscles during a sit-to-stand movement and leg extensor muscle strength after an 8-week preoperative HEP in women with severe KOA.
4. To assess the changes in knee function, functional mobility and perceived health status in women after an 8-week preoperative HEP in women with severe KOA.
5. To investigate the associations between motor function, functional mobility and perceived health outcomes in women with severe KOA.
6. To compare motor function and functional mobility characteristics between women with severe KOA and age- and gender-matched women without KOA, both before and after an 8-week preoperative HEP.

4. MATERIALS AND METHODS

4.1. Participants

The data of the participants are shown in Table 1. Twenty-eight women participated in this study: 18 women with severe KOA (KOA group) and 10 age-matched women without KOA (controls, CON group). All participants in the KOA group completed an 8-week HEP. The CON group did not participate in the HEP and was included for comparison to allow assessment of functional deficits in the KOA group relative to peers without KOA, both prior to and following the HEP.

Table 1. Data of participants.

Parameters	KOA group		CON group
	pre-HEP	post-HEP	
n	18	18	10
Age (years)	61.8 ± 1.6	62.0 ± 1.6	62.1 ± 1.8
Body mass (kg)	88.8 ± 3.8**	88.5 ± 3.7**	70.6 ± 4.1
Body height (cm)	161.8 ± 1.2	161.8 ± 1.2	161.1 ± 1.8
BMI (kg/m^2)	33.9 ± 1.4**	33.9 ± 1.4**	27.2 ± 1.3

BMI – body mass index; CON – control; HEP – home exercise program; KOA – knee osteoarthritis; n – number of participants; **p<0.01 compared to controls; $\bar{x}$± SE

All participants were informed about the aim and methods of the study. Participants voluntarily provided a written consent to participate, and their rights were protected. Models in the photos have given a consent for the photos to be used in scientific publications and presentations.

The study was part of a larger research project which investigated the effect of prehabilitation in women diagnosed with severe KOA undergoing TKA. The study protocol was performed in accordance with the Declaration of Helsinki, and it was approved by the Research Ethics Committee of the University of Tartu (protocol numbers 153/9 and 218/T-16). The trial was registered at ClinicalTrials.gov (identification number NCT02881463).

4.1.1. Recruitment of participants

Participants in the KOA group were identified and recruited by one and the same orthopaedic surgeon (TH) from patients listed for primary unilateral TKA at Tartu University Hospital, Estonia. The initial screening was made based on the predefined inclusion criteria: a diagnosis of primary KOA with radiological grades 3 and 4 according to the Kellgren & Lawrence (1957) classification, scheduled primary unilateral TKA, the ability to walk without a walking aid, no visual impairment with or without eyeglasses, and willingness to engage in a regular HEP. Potential participants were initially contacted by telephone to assess eligibility, introduce the study, and invite them to an outpatient clinic appointment. Following consent to participate, a research team member contacted the eligible patients to arrange the study appointment. The participant selection process is outlined in Figure 1.

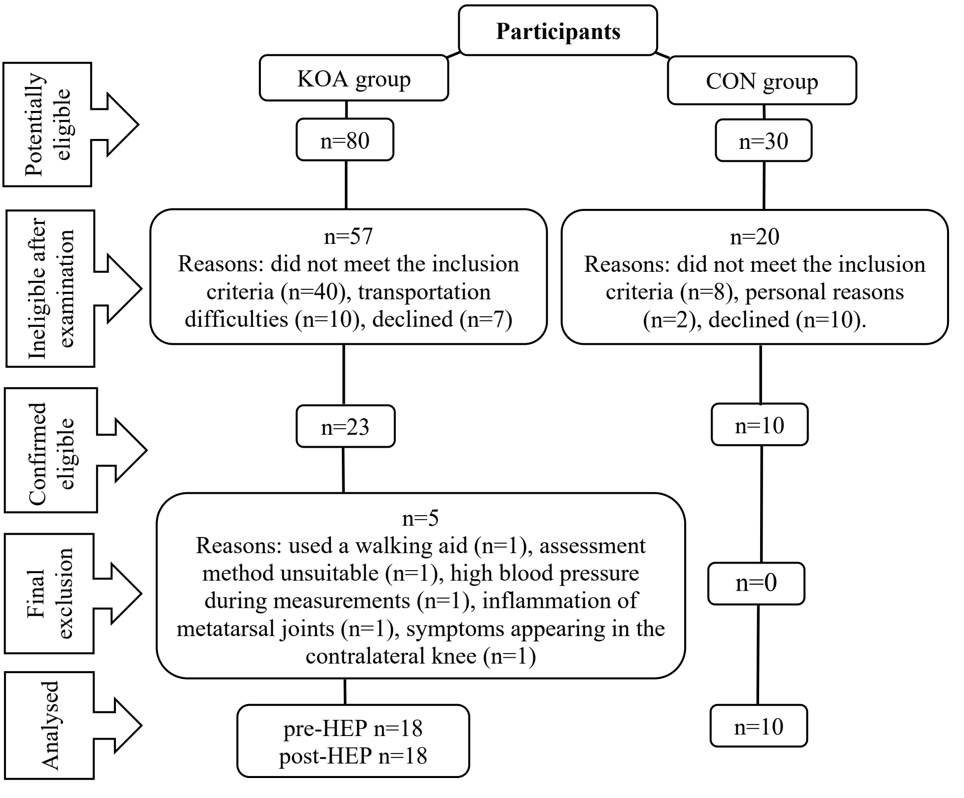

Figure 1. Selection of participants.

CON – control; HEP – home exercise program; KOA – knee joint osteoarthritis; n – number of participants.

Data from KOA group participants excluded during the final exclusion phase have not been used for the analysis (Figure 1). In accordance with ethical guidelines, these individuals still received exercise instructions and completed the HEP.

Participants in the CON group were recruited from the community by a research team member. An invitation to participate in the study was spread online, and potential participants were contacted via telephone. CON group participants were informed that they would undergo a single assessment and would not receive any intervention. The predefined inclusion criteria for the CON group were no participation in regular exercise training, no significant knee pain during the last 6 months (VAS less than 20/100 mm), and no radiological signs of KOA. The latter was confirmed via X-ray, performed before other evaluations by the same orthopaedic surgeon.

To minimize potential confounding factors, exclusion criteria for both groups included fractures or other significant trauma in the last 12 months, history of major lower limb surgery, and presence of systematic diseases, especially conditions or pathologies that could affect outcome measures, including disturbances in body balance and coordination.

4.2. Study design

The longitudinal intervention study design enabled assessment of the KOA group's baseline status before the intervention (pre-HEP) and evaluation of changes after the intervention (post-HEP) (Figure 2). The design also allowed for comparisons between the KOA group and a control group. The study was carried out by researchers from the Laboratory of Kinesiology and Biomechanics at the Institute of Sport Sciences and Physiotherapy in collaboration with the Department of Orthopaedics at the Institute of Clinical Medicine of the University of Tartu between 2011 and 2014.

Objective and subjective assessments were conducted to evaluate the effect of the preoperative HEP. KOA group was assessed twice: before and after performing the 8-week HEP. The CON group was assessed once. The analysis involved a comparison of pre- and post-HEP outcomes within the intervention group, and between-group comparisons with the control group at both assessments. The first assessment of the KOA group was approximately two months before TKA, and the participants began performing the HEP the day after the first assessment. The second assessment was approximately one day before TKA. All assessments were identical and were conducted in the morning. The time expenditure was about three hours per participant with rest pauses between tests. The assessments were carried out as individual assessments and on the day of the assessment the participants had not taken any inflammatory or pain-relieving medication.

During the assessments, participants were asked to rate their perceived pain, fear of falling, and health status. Anthropometric parameters (body height, body mass, foot length) were measured. Functional assessment included measurements of knee joint active range of motion (AROM), Timed Up and Go (TUG) test, static standing balance, bioelectric activity of the thigh muscles during the FTSST, gait analysis, and leg extensor muscle strength. At the end of the first assessment, a physiotherapist individually taught the HEP exercises to the KOA group participants.

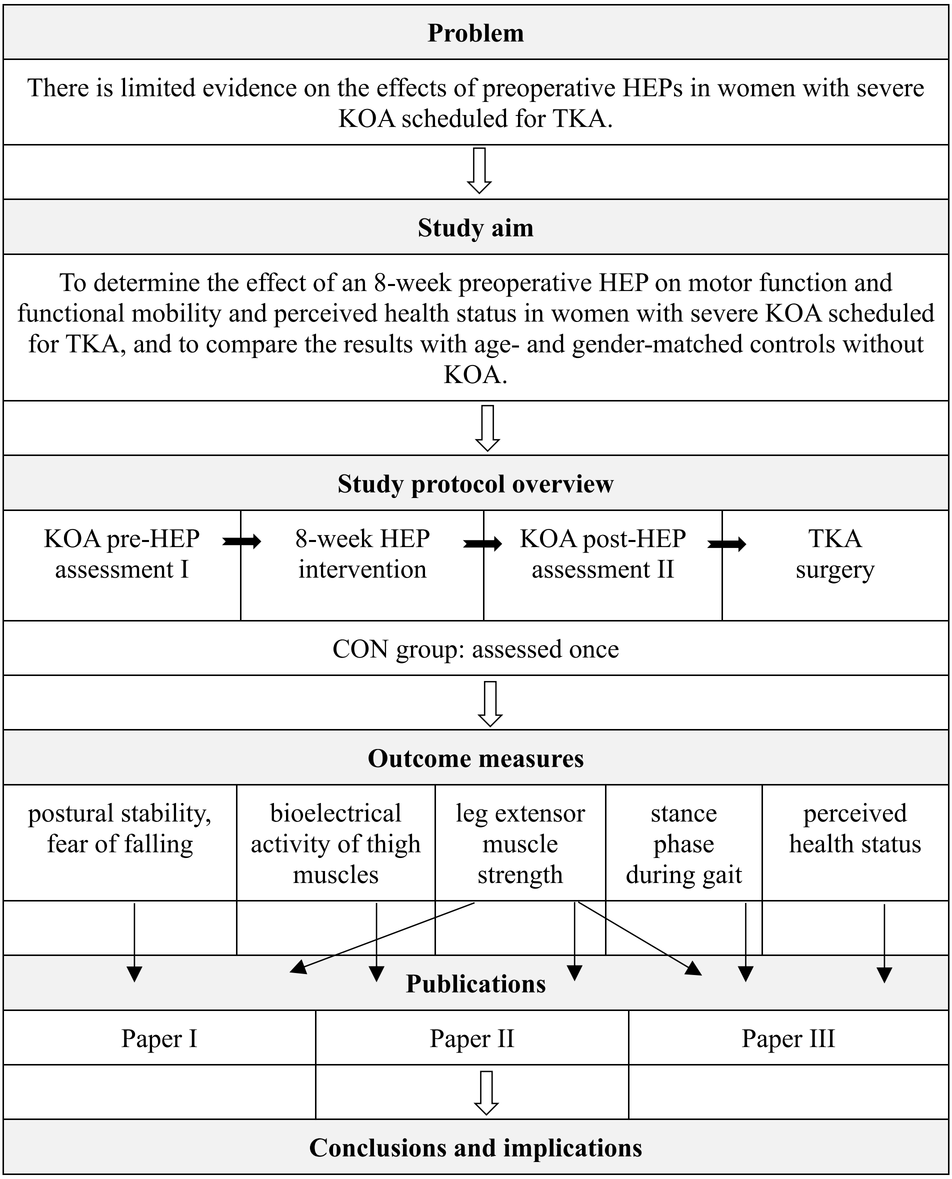

Figure 2. Study design.

HEP – home exercise program; KOA – knee osteoarthritis; CON – control; TKA – total knee arthroplasty

4.3. Preoperative home exercise program

The HEP consisted of 15 exercises aimed to improve muscle strength, knee range of motion, body balance, and coordination, with a particular focus on the lower limbs. The HEP included both standing and seated exercises that are simple and manageable for patients with severe KOA to perform independently at home (Deyle et al., 2005; Topp et al., 2009; Swank et al., 2011). Elastic bands were incorporated into seated exercises to add resistance, specifically targeting the lower limbs. An expert physiotherapist selected the exercise program, which was standardized for all participants in the KOA group.

Each participant in the KOA group received individual in-person instructions from the physiotherapist to ensure proper execution of the exercises, as well as a set of three elastic bands with different resistance levels, a training diary, and an illustrated exercise sheet with detailed descriptions to support correct exercise performance. Participants were assigned to perform the exercises daily during the whole intervention period. The 8-week HEP was distributed into weeks 1–8, and the exercise progression was adjusted according to weeks. The intensity of the HEP was increased by adding sets and number of repetitions and using an elastic band with higher resistance. The resistance was adjusted according to the manufacturer's specifications of the elastic bands (Theraband, USA) – green with a resistance of 1.3 kg, red with a resistance of 1.7 kg, and blue with a resistance of 2.1 kg (Theraband, 2025). As the exercises became easy, participants were instructed to advance to a higher-resistance band and follow structured weekly progression guidelines. Details on exercise progression, sets, repetitions, and descriptions are presented in the Appendix.

To monitor progress and support adherence, the physiotherapist contacted KOA group participants by telephone on a weekly basis. These phone calls also provided participants with an opportunity to receive feedback, ask questions, and obtain guidance on proper exercise techniques. Previous research indicates that exercise instruction and follow-up calls increase the effect of HEPs in individuals with KOA (Yilmaz et al., 2019; Mazières et al., 2008). When supervision is limited, printed exercise manuals can further support adherence and performance. This is important, as greater weekly participation in HEPs is associated with better outcomes (Carvalho et al., 2010; Juhl et al., 2014).

Participants in the KOA group filled out a training diary documenting details related to the HEP, including exercise duration, number of repetitions, training time, pain levels before and after each session, and additional physical activities during the day, such as time spent walking outdoors or the number of stairs climbed. In the current study, the training diary was analysed solely for information related to general HEP adherence.

4.4. Outcome measures

The outcome measures included anthropometric measurement, objective motor function and performance measures, including leg extensor muscle strength, thigh muscle bioelectrical activity, gait and postural stability measurements, and functional tests. In addition, subjective outcome measures were assessed, including perceived health status, pain and fear of falling. These measures are consistent with the most common symptoms and dysfunctions in KOA patients and are widely used to assess the effectiveness of KOA rehabilitation programs.
In the KOA group, the leg scheduled for TKA was defined as the involved limb, with the contralateral leg considered the uninvolved limb. For the CON group, the data of the dominant limb − the preferred leg for kicking a ball − was used (van Melick et al., 2017).

4.4.1. Anthropometric measurements

Body height was measured with a wall-mounted stadiometer (±0.1 cm) and body mass was measured with a medical electronic scale (±0.05 kg). The participants wore similar light clothing (shorts and a t-shirt or sleeveless shirt) and did not wear shoes during the measurements. Foot length was measured barefoot during standing with an extendable anthropometer (Lafayette, USA) from the farthest point of the heel to the tip of the longest toe (hallux or 2nd toe).

4.4.2. Postural stability measurement

Postural stability was measured using a force platform (Kistler 9286A, Switzerland). The participant was instructed to stand on the force plate, feet hip-width apart, for 30 seconds with eyes open and look straight ahead on a mark adjusted to the eye level. Postural sway was analysed on a stable firm surface (Figure 3A) and a unstable foam surface (Airex balance pad, Switzerland; standard height 6.5 cm) (Figure 3B).

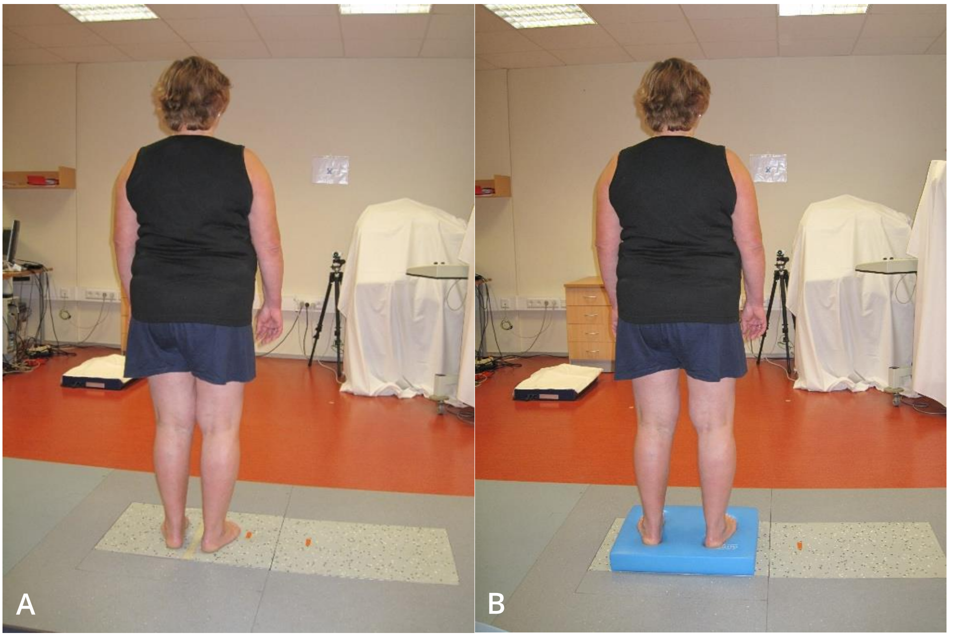

Figure 3. Postural stability measurement on the firm (A) and foam (B) surface.

The following postural sway characteristics were recorded with the Elite Clinic (BTS S.p.A., Italy) movement analysis system SWAY® software: the centre of pressure (COP) anterior-posterior and mediolateral sway (mm); the sway length (trajectory) (mm), radius (mm), and equivalent area (mm^2). To reduce the influence of anthropometric characteristics, postural sway data were adjusted to the participant's height (m) and foot length (mm) (Chiari et al., 2002).

4.4.3. Gait analysis

Gait characteristics were measured with an instrumented three-dimensional gait analysis system, which is a valid method for describing changes in gait in patients with KOA (Favre & Jolles, 2017). The gait analysis was performed using an optoelectronic motion analysis system (ELITE, BTS, Italy) with six infra-red cameras (sampling rate 100 Hz) to measure sagittal kinetic and spatiotemporal gait characteristics. Vertical ground reaction force (GRF) was measured with two force platforms (sampling rate 500 Hz) (Kistler 9286A, Switzerland). Reflective markers (1.5 cm in diameter) were placed on specific anatomical points in accordance with the Helen Hayes protocol, using the Davis biomechanical model (Davis et al., 1991). These anatomical points were: C7 and L4 processus spinosus, acromion, anterior superior iliac spines, lateral femoral trochanters, lateral mid-thigh, lateral femoral epicondyle, lateral tibial epicondyle, lateral mid-shank, lateral malleolus, lateral side of the foot on the fifth metatarsal head, and calcaneus (Figure 4A).

During the measurement, the participant was instructed to walk along a 5.8 m walkway at a self-selected comfortable speed (Figure 4B). Five trials were performed, and the trial with the most stable walking speed was analysed. Gait measurement data were stored and analysed using ELITE Clinic software (BTS SpA, Italy). The data analysis included spatiotemporal parameters such as stance time (%), cadence (steps/min), mean velocity (m/s), step length (m), stride length (m) and step width (m). Sagittal kinetics parameters such as knee extension moment (KEM, N·m/kg) and vertical GRF (N) were analysed during loading response of gait. GRF and KEM data were normalised to body mass (kg).

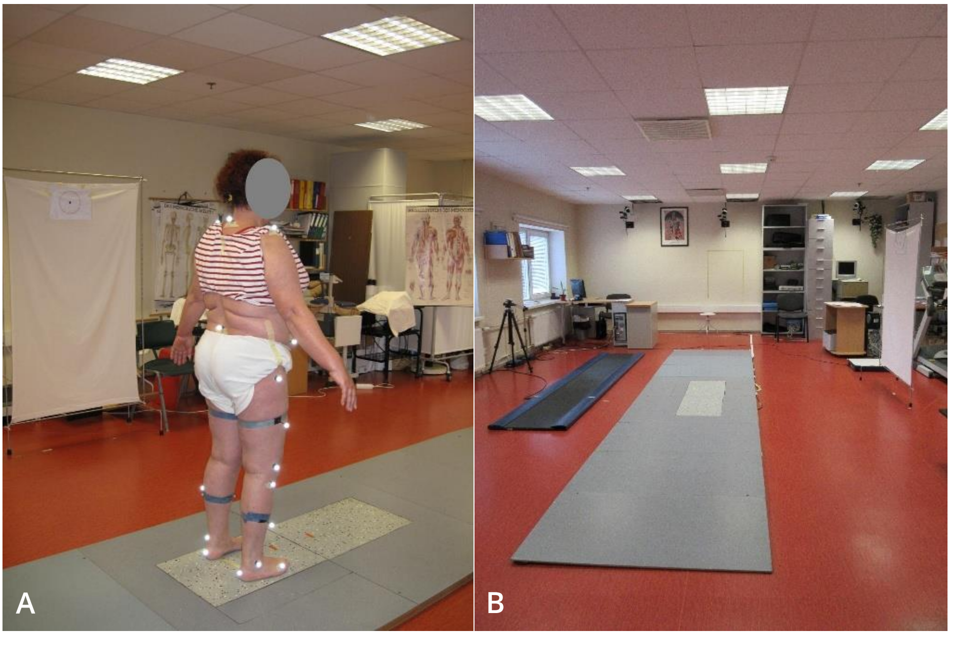

Figure 4. Marker placement during gait analysis (A), and gait analysis setting (B)

4.4.4. Thigh muscle bioelectrical activity measurement

The bioelectrical activity of rectus femoris, vastus lateralis, vastus medialis, biceps femoris and semitendinosus muscles were recorded bilaterally during the FTSST using a 16-channel electromyograph (Mega Electronics, Finland). The skin was cleaned, and standard bipolar electromyography (EMG) electrodes (Noraxon, USA) were placed parallel to the muscle fibres over the centre of the muscle bellies according to the SENIAM guidelines (Hermens et al., 2000; Merletti & Hermens, 2000). Knee range of motion was synchronously measured with electrogoniometers SG150 (Biometrics Ltd., UK), which were attached to the lateral aspect of both knee joints (Figure 5).

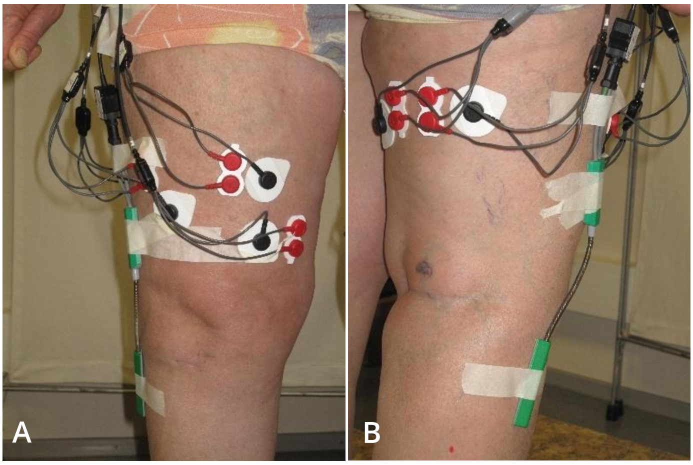

Figure 5. Placement of electromyography electrodes on knee extensors (A, anterior view) and flexors (B, posterior view) as well as position of electrogoniometers.

The collected surface EMG data were stored and analysed using MegaWin software (Mega Electronics, Finland). The signal was amplified (x1000) and band-pass filtered between 10–500 Hz. EMG data from the fastest FTSST trial were analysed. Each repetition of the FTSST was divided into two continuous movements: concentric (from sitting to standing) and eccentric (from standing to sitting). These movements were identified using EMG bursts and knee joint angles. The mean of the first and fifth repetitions was used for further analysis, indicating the beginning and end of the FTSST. Root mean square (RMS) values were calculated for both movements and normalised to the maximal voluntary contraction (MVC) EMG activity. Normalising RMS to MVC EMG activity provides a reliable approach for assessing functional performance and comparing activation levels across muscles (Renshaw et al., 2010; Cronin et al., 2015; Pincheira et al., 2017).

4.4.5. Leg extensor muscle strength measurement

To assess isometric leg extensor muscle strength through MVC force and rate of force development, measurements were taken using a horizontal custom-made dynamometric chair (leg press, Figure 6) as closed-chain assessment method has shown to offer enhanced insight into functional limitations of patients after TKA compared to traditional open-chain measurements of knee extensor strength (Rossi et al., 2007). During the measurement, the participant sat on the chair with knee and hip joints flexed 110–120°, the position was secured with a Velcro belt placed over the hips to avoid sliding forward, and the participant's foot or feet were placed on the footplate (Raudsepp & Pääsuke, 1995).

During the measurement of unilateral and bilateral isometric MVC force, the participant was instructed to push against the footplate with maximal force for two seconds, while the force output was recorded using a standard strain gauge transducer (1778 DST-2, Russia). Verbal_encouragement was provided to elicit maximum effort; no sub-maximal contractions were performed in preparation for the measurement. In the KOA group, all measurements were first performed on the uninvolved limb, followed by the involved limb. For the CON group, assessments were conducted on the dominant limb. Each participant completed three trials, with a one-minute rest between trials. The biggest result was considered for analysis.

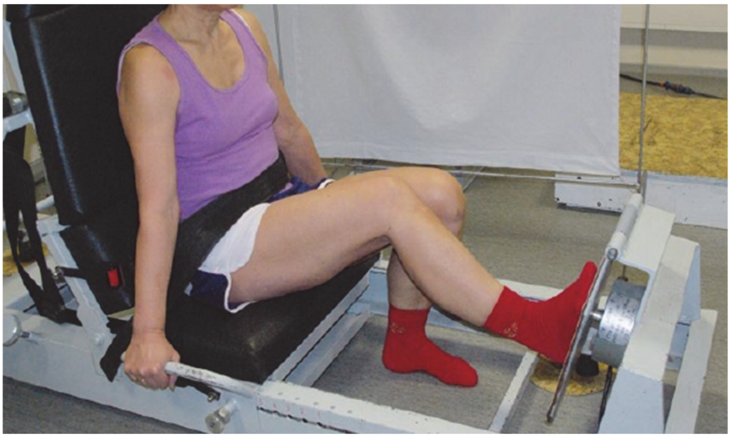

Figure 6. Measurement of unilateral isometric maximal voluntary contraction force of leg extensor muscles on a dynamometric chair.

To measure the rate of force development, the participant was instructed to push against the footplate with maximal effort as quickly as possible when a signal light turned on and relax once the light turned off. The signal light was on for two seconds. Three trials were performed with a two-minute resting period between trials. The highest result of MVC was considered and rate of force development (RFD, N/s) at 50% of MVC was analysed.

The leg extensor muscle strength data were adjusted to anthropometric parameters (body height and body mass) to better analyse the differences in muscle strength among individuals with different outcomes (Hurd et al., 2011). The isometric MVC force of leg extensor muscles was analysed as unilateral and bilateral peak torque (PT, N·m) and peak torque-to-body mass (PT-to-BM) ratio ($N \cdot m \cdot kg^{-1}$) and rate of force development at 50% of MVC as rate of peak torque development (RPTD, $N \cdot m \cdot s^{-1} \cdot kg^{-1}$).

4.4.6. Functional tests

Functional ability was evaluated using a combination of standardised objective measures, including goniometry, the FTSST, and the TUG, as detailed in Table 2.

Table 2. Description of knee function and functional mobility assessments

Active range of motion (AROM)	**Characteristic:** Active knee flexion range of motion (AROM flex) and active knee extension range of motion (AROM ext). **Description:** AROM flex was measured with the participant in the prone position, AROM ext in the supine position. A goniometer centre was placed in the middle of the lateral femoral epicondyle, the movable arm aligned with the fibula, and the stationary arm aligned with the femur. Participants were instructed to perform maximal knee flexion or extension. Pelvic tilting was prohibited. **Scoring:** Measured with a long-arm goniometer (Baseline, USA) in degrees. Three measurements for each movement were done, the greatest result was taken for analysis. ***Clinimetrics:** Goniometers are reliable and accurate for assessing knee joint range of motion (Hancock et al., 2018).
Five Times Sit-to-Stand test (FTSST)	**Characteristic:** Lower limb functional strength. **Description:** The participant sat on an adjustable chair with knees flexed at 90° and was instructed to perform five sit-to-stands as fast as possible. The timer was stopped when the participant was fully seated. The use of hand support was prohibited. A shorter performance time reflected better mobility. **Scoring:** Time (s) to perform five sit-to-stands was measured with a stopwatch. The test was repeated after a one-minute resting period. Fastest result was used for analysis and EMG data. **Clinimetrics:** The FTSST is a widely used in clinical and research settings for KOA patients (Whitney et al., 2005; Tapanya et al., 2024). It has strong test-retest reliability in individuals with KOA, and even small changes in performance are considered clinically meaningful (Kaszyński et al., 2022).
Timed Up & Go test (TUG)	**Characteristic:** Mobility, dynamic balance and lower extremity function. **Description:** The participant was seated on a chair with a marker cone 3 m from the chair. Upon command, the participant stood up, walked around the marker from the right side as quickly as possible, then returned and sat down. A shorter performance time reflected better mobility. **Scoring:** The time (s) was measured with a stopwatch. The timer was stopped when the participant was fully seated. One practice trial was done, followed by two test trials, with a two-minute rest period between trials. Fastest result was used for analysis. **Clinimetrics:** TUG is a widely used sensitive, reliable, and valid method for assessing patients with orthopaedic complications and various interventions (Herman et al., 2011; Sarac et al., 2022).

*Clinimetrics – a methodological field that concentrates on the quality and accuracy of clinical measurements (de Vet et al., 2003).

4.4.7. Self-reported health status measures

Self-reported outcomes like perceived knee joint pain, fear of falling and health status were evaluated using standardized and validated questionnaires, including WOMAC, VAS, and the Modified Falls Efficacy Scale (MFES), as detailed in Table 3.

Table 3. Descriptions of self-reported outcome measures

Modified Falls Efficacy Scale (MFES)	**Characteristic:** Perceived fear of falling. **Description:** 14 items scored based on "How confident are you that you can do each of the activities without falling?". The questionnaire was explained to the participant, who then filled it out. **Scoring:** Scored on a 10-point scale, where 0 points meant "not confident at all" and 10 points meant "completely confident". Total score was calculated as the average of all items. Higher score indicated greater confidence. **Clinimetrics:** The MFES questionnaire has a high retest reliability in older people (Hill et al., 1996).
Visual Analog Scale (VAS)	**Characteristic:** Perceived knee joint pain intensity **Description:** The participant was instructed to reflect on the pain she had experienced over the past 7 days and provide a rating of the average pain on a 100 mm visual analogue scale. **Scoring:** Values in mm were transformed to point scale where 10 mm was equal to 1 point. 0 points indicated no pain, and 10 points indicates maximal pain. **Clinimetrics:** VAS is a reliable pain measure in osteoarthritis patients (Alghadir et al., 2018).
Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)	**Characteristic:** Perceived KOA-related health status **Description:** The questionnaire consists of 24 questions answered on 5-point Likert scale and divided into pain (5 questions), stiffness (2 questions) and function (17 questions) subscales. The questionnaire was explained to the participant, who then filled it out. **Scoring:** The WOMAC index was calculated (WOMAC index = score × 100/96) and analysed on a scale of 0–100. Higher scores indicated better health status (Holtz et al., 2020). **Clinimetrics:** The WOMAC questionnaire is a valid, reliable, and efficient lower limb osteoarthritis-specific outcome measure (Ackerman, 2009; Holtz et al., 2020).

4.5. Statistical methods

Power analysis indicated that a sample size of 15 was sufficient to achieve a 95% confidence level for detecting the effect of HEP on thigh muscle bioelectrical activity and leg extensor muscle strength in the KOA group, while 18 participants was required to detect changes in gait characteristics. The Shapiro-Wilk test was used to assess the normality of the data distribution. Data were analysed using the SPSS 20 (IBM, USA) and Statistica 13 software (TIBCO Software, USA). A one-way analysis of variance (ANOVA) followed by the independent sample t-test (Paper III) or Tukey post-hoc (Paper I & II) comparisons were used to evaluate differences between the KOA and CON groups, as well as between involved and uninvolved limb in KOA group. The paired sample t-test (Paper I & III) or the Bonferroni test (Paper II) were used for evaluating differences in the KOA group's pre- and post-HEP results. Pearson and Spearman correlation coefficients were calculated to examine associations between variables (Paper I & III). 95% Confidence Interval (CI 95%) were calculated for subjective measurements (WOMAC and VAS) (Paper III). Statistical significance was set at $p<0.05$. Clinical effect size was determined using Cohen's d, and differences were considered clinically significant when CES ≥ 0.4 (Paper II & III) (Armijo-Olivo et al., 2011).

5. RESULTS

Results for the KOA group are presented for 17 participants in Papers I and II, and for 18 participants in Paper III due to the inclusion of one additional participant later in the study. KOA group performed the HEP average of 25 minutes a day for at least 8 weeks. No negative events related to the HEP occurred and the drop-out rate during HEP was 0%. 13 out of the 18 KOA group participants proceeded with TKA, while five opted to delay the surgery.

5.1. Postural stability

Following the HEP, COP sway length on the unstable foam surface was significantly reduced in the KOA group ($p<0.05$; Figure 7D).

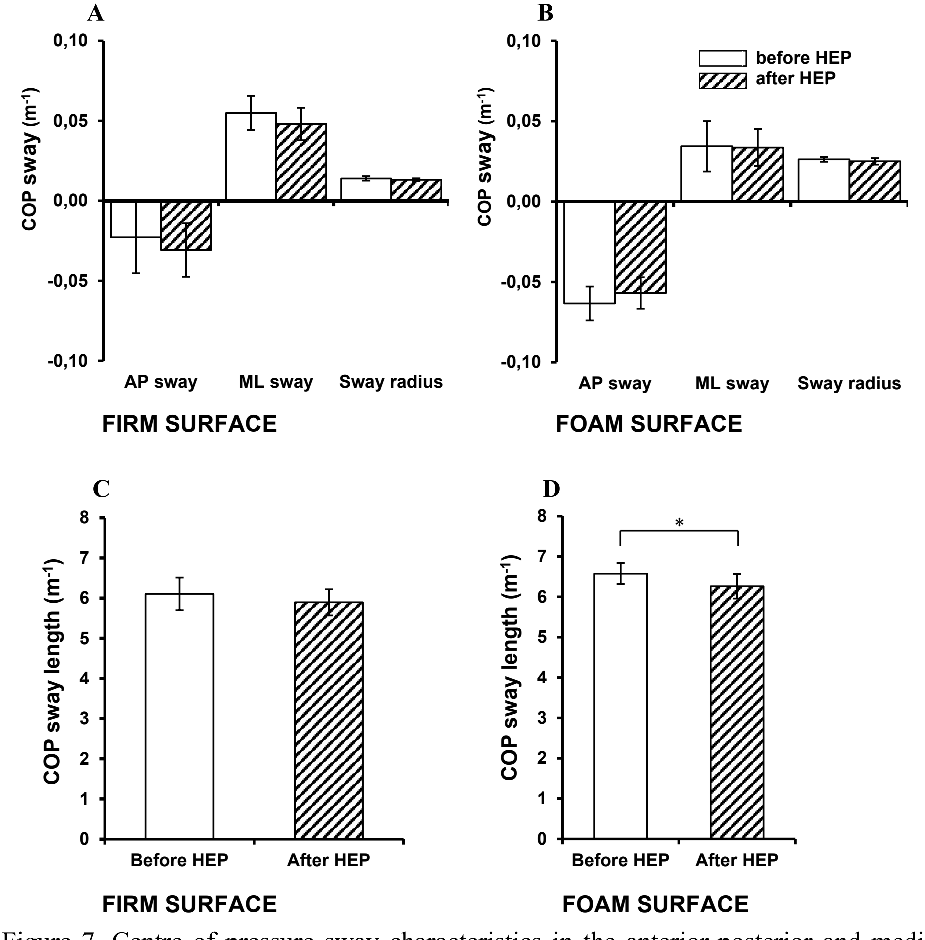

Figure 7. Centre of pressure sway characteristics in the anterior-posterior and mediolateral directions, sway radius, and sway length (trajectory) during quiet standing on firm (A, C) and foam (B, D) surfaces in women with severe knee osteoarthritis before and after a preoperative home exercise program. Data were adjusted to the participant's height (m) and foot length (mm).

AP – anterior-posterior; HEP – home exercise program; ML – mediolateral; *$p<0.05$ pre-HEP compared to post-HEP; $\bar{x}\pm$ SE.

No significant changes were observed on the firm surface (Figure 7C). COP sway in the anterior-posterior and mediolateral directions, sway radius (Figure 7A, 7B), and sway area did not differ on either surface compared to pre-HEP.

5.2. Gait characteristics

Spatiotemporal characteristics in the KOA group did not change significantly post-HEP compared to pre-HEP. Significant differences ($p<0.05$) were observed in all spatiotemporal parameters of the KOA group both pre- and post-HEP, when compared to the CON group, except for step width (Table 4).

Table 4. Spatiotemporal gait characteristics in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls.

Parameters	**KOA group**		**CON group**
	pre-HEP	post-HEP	
Stance time (%)	58.99 ± 0.55 *	58.95 ± 0.43 *	57.33 ± 0.36
Cadence (steps/min)	107.36 ± 2.01 ***	111.41 ± 2.62 **	124.41 ± 2.86
Mean velocity (m/s)	1.12 ± 0.04 ***	1.12 ± 0.06 ***	1.46 ± 0.04
Stride length (m)	1.22 ± 0.03 ***	1.23 ± 0.04 **	1.41 ± 0.03
Step length (m)	0.62 ± 0.02 ***	0.61 ± 0.02 ***	0.72 ± 0.02
Step width (m)	0.08 ± 0.01	0.10 ± 0.01	0.10 ± 0.01

CON – control, HEP – home exercise program, KOA – knee osteoarthritis; *p<0.05, **p<0.01, ***p<0.001 KOA group compared to CON group; x̄± SE.

Following the HEP, the KEM during the loading response phase of gait in the involved limb showed no significant change in the KOA group, however it demonstrated tendency toward improvement (p=0.057, CES=0.23). Before the HEP, the KEM was significantly lower in the KOA group than the CON group ($p<0.05$), but this difference was no longer significant post-HEP (Figure 8).

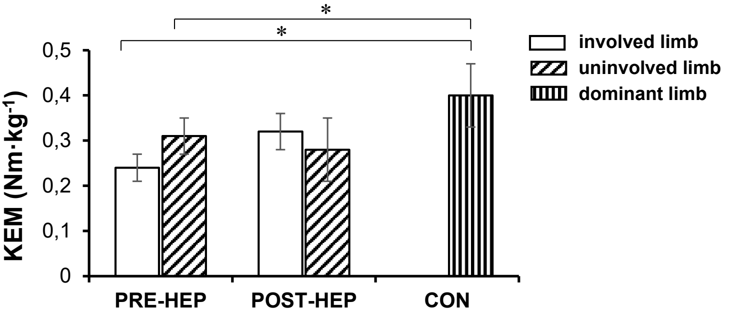

Figure 8. Knee extension moment during the loading response phase of gait in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls. Data were normalised to body mass (kg).

CON – control group; HEP – home exercise program; KEM – knee extensor moment; involved limb – leg scheduled for TKA in the KOA group; uninvolved limb – other leg in the KOA group; dominant limb – dominant leg in the CON group; *p<0.05 KOA group compared to CON group; x̄± SE

In the KOA group, the vertical GRF of the involved limb increased significantly post-HEP compared to pre-HEP (p<0.01, CES=0.35). GRF of the involved limb was significantly lower than the uninvolved limb pre-HEP (p<0.05); the difference was no longer significant post-HEP. Compared to the CON group, the KOA group's involved limb demonstrated significantly lower GRF both pre-HEP (p<0.001) and post-HEP (p<0.05) (Figure 9).

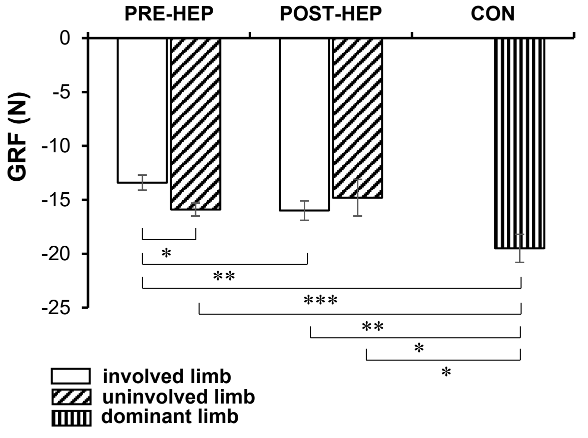

Figure 9. Vertical ground reaction force during the loading response phase of gait in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls. Data were normalised to body mass (kg).

CON – control group; GRF – ground reaction force; HEP – home exercise program; involved limb – leg scheduled for TKA in the knee osteoarthritis group; uninvolved limb – other leg in the knee osteoarthritis group; dominant limb – dominant leg in the CON group; *p<0.05; **p<0.01, ***p<0.001; x̄± SE.

5.3. Bioelectrical activity of thigh muscles during FTSST

Following the HEP, during the concentric phase of the sit-to-stand movement, the KOA group showed a significant reduction in the bioelectrical activity of the antagonistic knee flexor muscles of the involved limb (p<0.05; biceps femoris CES=0.55, semitendinosus CES=0.91) (Figure 10B). No significant changes were noted in the knee extensor muscles of the involved limb (Figure 10A).

Pre-HEP, the KOA group showed significantly higher bioelectrical activity in the biceps femoris, vastus lateralis and vastus medialis muscles of the involved limb compared to the uninvolved limb (p<0.05; vastus lateralis CES=0.79, vastus medialis CES=0.7, biceps femoris CES=0.69). Post-HEP, the bioelectrical activity asymmetry in the biceps femoris and vastus lateralis muscle decreased. Knee flexor (biceps femoris and semitendinosus) muscles bioelectrical activity was significantly higher in the KOA group than the CON group pre-HEP (p<0.01), yet no significant difference between groups was noted post-HEP. Knee extensor muscle activity in the KOA group was significantly higher compared to the CON group both pre-HEP and post-HEP (p<0.01).

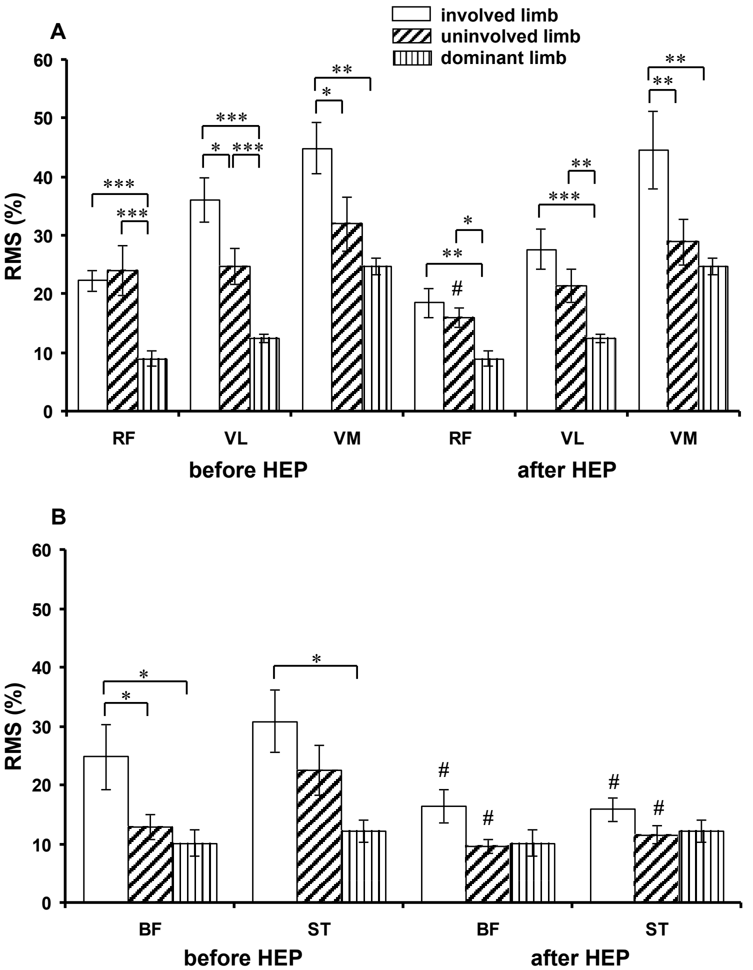

Figure 10. Bioelectrical activity of knee extensors (A) and flexors (B) during the concentric phase of the Five Times Sit-to-Stand test in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls. Data were normalised to maximal voluntary contraction bioelectrical activity.

BF – biceps femoris; HEP – home exercise program; RF – rectus femoris; RMS – root mean square; ST – semitendinosus; VL – vastus lateralis; VM – vastus medialis. Involved limb – leg scheduled for TKA in the KOA group; uninvolved limb – other leg in the KOA group; dominant limb – dominant leg in the CON group; $^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ involved limb compared to uninvolved limb and KOA group compared to CON group; $^{\#}p<0.05$ pre-HEP compared to post-HEP; $\bar{x} \pm$ SE.

Following the HEP, during the eccentric phase, the KOA group showed a significant reduction in the bioelectrical activity of the antagonistic knee extensor muscles (rectus femoris muscle) of the involved limb ($p<0.05$; CES=0.83) (Figure 11A), yet no significant changes were noted in the agonistic knee flexor muscles (Figure 11B). Both knee flexor and extensor muscles of the KOA group demonstrated higher bioelectrical activity in the involved limb compared to the uninvolved limb pre-HEP ($p<0.05$; biceps femoris CES=1.1, vastus lateralis CES=1.2, vastus medialis muscle CES=1.3) and post-HEP (p<0.05; biceps femoris CES=1.3, vastus lateralis CES=0.9, vastus medialis CES=1.3). Compared to the CON group, the KOA group demonstrated higher activity in all knee extensor muscles (p<0.01) but not knee flexor muscles in both pre-HEP and post-HEP.

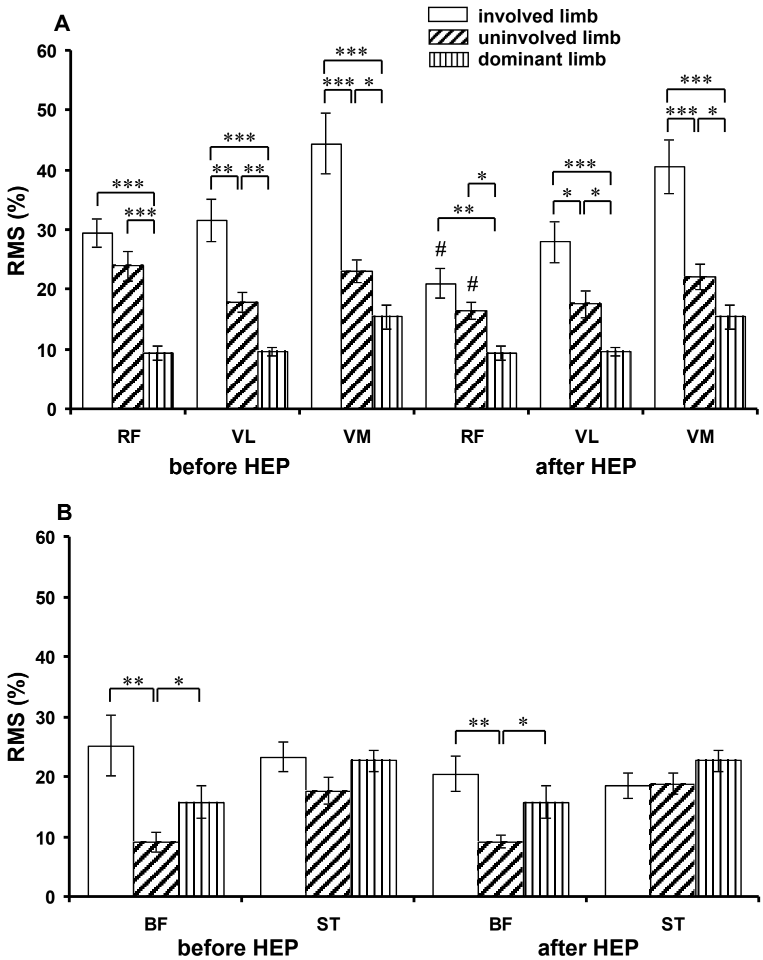

Figure 11. Bioelectrical activity of knee extensors (A) and flexors (B) during the eccentric phase of the Five Times Sit-to-Stand test in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls. Data were normalised to maximal voluntary contraction bioelectrical activity.

RF – rectus femoris, VL – vastus lateralis, VM – vastus medialis, BF – biceps femoris, ST – semitendinosus, RMS – root mean square; involved limb – leg scheduled for TKA in the KOA group; uninvolved limb – other leg in the KOA group; dominant limb – dominant leg in the CON group; *p<0.05, **p<0.01, ***p<0.001 involved limb compared to uninvolved limb and KOA group compared to CON group; #p<0.05 pre-HEP compared to post-HEP; x̄± SE.

5.4. Leg extensor muscle strength

Following the HEP, significant increase was noted in the unilateral isometric PT ($p<0.001$, CES=0.77) and PT-to-BM ratio ($p<0.01$, CES=0.77) of leg extensor muscles of the involved limb in the KOA group (Figure 12). The bilateral PT increased significantly from 533.8±62.7 to 679.3±101.7 N·m ($p<0.05$) and bilateral PT-to-BM ratio from 6.1±0.7 to 7.7±0.9 $N \cdot m \cdot kg^{-1}$ ($p<0.05$).

KOA groups' unilateral isometric PT and PT-to-BM ratio of the involved limb were significantly lower pre-HEP compared to the uninvolved limb ($p<0.01$), yet no significant difference between limbs was noted post-HEP. KOA group's PT-to-BM ratio of the involved limb remained lower compared to the CON group's data (6.2±0.7 $N \cdot m \cdot kg^{-1}$) both pre-HEP and post-HEP ($p<0.001$).

Post-HEP, the KOA group demonstrated significant increase in the isometric RPTD at 50% of maximal voluntary contraction force of the leg extensor muscles compared to pre-HEP ($p<0.01$, CES 0.42). However, this characteristic was significantly lower than the CON group at both assessments ($p<0.001$) (Figure 13).

Pre-HEP, PT of the involved leg was negatively correlated with COP sway radius on a foam surface ($r=-0.50$, $p<0.05$) and RPTD was positively correlated with KEM ($r=0.47$, $p<0.05$) and negatively correlated with step width ($r=-0.61$, $p<0.01$).

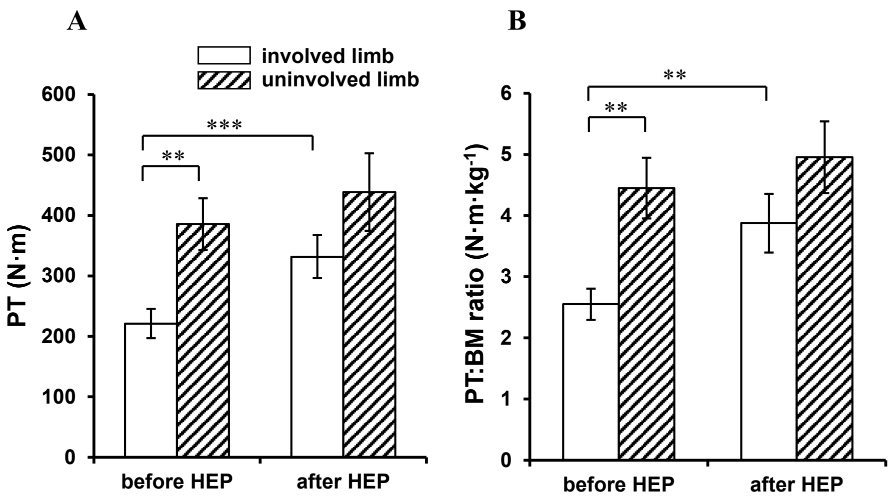

Figure 12. Unilateral isometric peak torque (A) and peak torque-to-body mass ratio (B) of leg extensor muscles in women with severe knee osteoarthritis before and after a pre-operative home exercise program. Data were normalised to body mass (kg) and height (mm).

HEP – home exercise program; PT – peak torque; PT-to-BM – peak torque-to-body mass ratio; involved limb – leg scheduled for TKA in the KOA group; uninvolved limb – other leg in the KOA group; **$p<0.01$, ***$p<0.001$; $\bar{x}\pm$ SE.

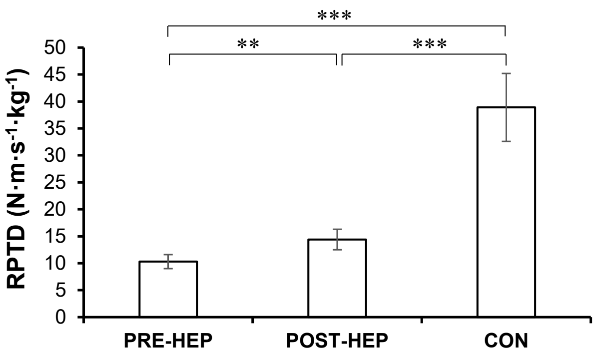

Figure 13. Isometric relative peak torque development of leg extensor muscles at 50% maximum voluntary contraction force in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls. Data were normalised to body mass (kg) and height (cm).

CON – control group; HEP – home exercise program; RPTD – relative peak torque development; **$p<0.01$ and ***$p<0.001$; $\bar{x}\pm$ SE.

5.5. Functional tests

FTSST time improved in the KOA group, with participants completing the test 2.6 s faster post-HEP compared to pre-HEP ($p<0.05$); however, they performed the test significantly slower than the CON group at both assessments ($p<0.01$) (Table 5). TUG test time in the KOA group did not change significantly post-HEP, although the KOA group participants were significantly slower than the CON group only pre-HEP ($p<0.05$) (Table 5).

Table 5. Functional performance in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls.

Parameters	KOA pre-HEP	KOA post-HEP	CON
n	18	18	10
FTSST (s)	$15.5 \pm 2.3^{\#\#}$	$12.9 \pm 1.5^{\#\#,*}$	6.7 ± 0.4
TUG (s)	$9.1 \pm 0.99^{\#}$	9.0 ± 1.20	5.9 ± 0.27
AROM flex (◦) involved limb	$90.9 \pm 4.6^{\#\#\#,\&\&\&}$	$99.8 \pm 3.8^{**,\#\#\#,\&\&}$	122.8 ± 2.0
AROM flex (◦) uninvolved limb	108.9 ± 2.3	113.8 ± 1.9	N/A
AROM ext (◦) involved limb	$-7.5 \pm 2.0^{\#\#,\&\&}$	$-6.9 \pm 1.7^{\#\#,\&\&}$	-0.1 ± 0.1
AROM ext (◦) uninvolved limb	-0.5 ± 0.4	0.0 ± 0.0	N/A

AROM flex – active knee flexion range of motion; AROM ext – active knee extension range of motion; CON – control group, FTSST – Five Times Sit-to-Stand test; HEP – home exercise program; KOA – knee osteoarthritis group, n – number on participants; N/A – not applicable; TUG – Timed Up & Go test; VAS – visual analog scale (0–10 points); *$p<0.05$, **$p<0.01$ post-HEP compared to pre-HEP; &&$p<0.01$, &&&$p<0.001$ involved limb compared to uninvolved limb; #$p<0.05$, ##$p<0.01$ and ###$p<0.001$ KOA group compared to CON group; $\bar{x}\pm$SE.

AROM flex of the involved limb in the KOA group significantly increased post-HEP ($p<0.01$, CES=0.48) but remained significantly lower than the uninvolved limb ($p<0.01$) and the CON group ($p<0.001$) (Table 5). The KOA group had a knee extension deficit pre-HEP and post-HEP.

5.6. Self-reported measures

Following the HEP, the KOA group showed a significant improvement in the WOMAC total index compared to pre-HEP ($p<0.05$, CES=0.52) (Table 6). A significant reduction in pain was reflected in higher WOMAC pain subscale score ($p<0.01$, CES=0.24). The function subscale showed a clinically meaningful improvement (CES=0.39); however, this change was not statistically significant. Across all subscales and the WOMAC total index, the KOA group consistently scored significantly poorer than the CON group at both assessments ($p<0.001$).

The post-HEP VAS score did not differ significantly compared to pre-HEP (Table 6). The MFES score increased from 7.9 ± 0.6 pre-HEP to 8.2 ± 0.6 post-HEP; however, this change was not statistically significant.

Table 6. Self-reported health status and knee pain in women with severe knee osteoarthritis before and after a preoperative home exercise program, compared to controls.

	Parameters	KOA group		CON group
		pre-HEP	post-HEP	
WOMAC	Pain	11.33 ± 1.18 ###	13.56 ± 0.97 **,###	19.50 ± 0.22
	CI 95%	10.79 – 11.88	13.11 – 14.00	19.36 – 19.64
	Stiffness	4.17 ± 0.55 ###	4.44 ± 0.55 ###	8.00 ± 0.00
	CI 95%	3.91 – 4.42	4.19 – 4.70	8.00 – 8.00
	Function	37.83 ± 3.71 ###	44.33 ± 3.07 ###	67.40 ± 0.34
	CI 95%	36.12 – 39.55	42.91 – 45.75	98.51 – 99.19
	Total index	55.55 ± 5.28 ###	65.74 ± 4.66 *,###	98.85 ± 0.55
	CI 95%	53.1 – 57.99	63.59 – 67.89	98.51 – 99.19
VAS (points)		5.14 ± 0.42 ###	4.47 ± 0.45 ###	0.2 ± 0.15
	CI 95%	4.95 – 5.34	4.26 – 4.67	0.11 – 0.29

CI 95% – confidence intervals at 95%; CON – control; HEP – home exercise program; KOA – knee osteoarthritis; VAS – Visual Analogue Scale; WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index; *$p<0.05$ and **$p<0.01$ post-HEP compared to pre-HEP; ###$p<0.001$ KOA group compared to CON group; $\bar{x}$± SE.

Pre-HEP, the WOMAC subscales and total index were negatively correlated with VAS scores ($p<0.05$, r =–0.51 to –0.69) and positively correlated with knee joint AROM flexion ($p<0.05$, r=0.51 to 0.59) and isometric RPTD ($p<0.05$, r=0.55 to 0.62) pre-HEP. After HEP, the significant negative correlations between VAS and WOMAC persisted ($p<0.01$, r=–0.68 to –0.81).

Pre-HEP, the VAS score positively correlated with COP sway radius on a foam surface ($r=0.52$, $p<0.05$) and negatively correlated with the isometric PT of the leg extensor muscles of the involved leg ($r=-0.54$, $p<0.05$) and knee joint flexion AROM ($r=-0.61$, $p<0.01$). Post-HEP, the VAS score positively correlated with COP mediolateral sway on foam surface ($r=0.51$, $p<0.05$).

Pre-HEP, the MFES score was significantly correlated with the isometric PT of the leg extensor muscles of the involved leg ($r=0.46$, $p<0.05$), the isometric PT-to-BM ratio of the involved leg ($r=0.67$, $p<0.05$), and the bilateral isometric leg extensor muscles PT ($r=0.50$, $p<0.05$).

6. DISCUSSION

This study aimed to evaluate the effect of an 8-week HEP including resistance, stretching, balance, and coordination exercises, combined with weekly physiotherapist phone calls, on motor function and functional mobility in women with severe KOA scheduled for TKA. The main findings of this study revealed that performing an 8-week preoperative HEP (1) improves postural stability on an unstable surface, (2) improves KEM and GRF during loading response of gait, (3) improves muscle bioelectrical activation and reduces co-contraction of thigh muscles, (4) increases isometric leg extensor muscle strength and rate of force development, (5) decreases asymmetry of muscle strength and bioelectrical activity between limbs (6) improves functional performance, and perceived health status in women with severe KOA scheduled for TKA. The 8-week HEP does not influence gait spatiotemporal parameters and knee pain intensity. Following the HEP, the KOA group participants' KEM during the loading response phase of gait and bioelectrical activity of knee flexors during sit-to-stand movement do not differ compared to age- and gender-matched controls. Other measured outcomes remain poorer compared to the CON group.

6.1. The effect of HEP on postural stability

Previous studies have shown that individuals with KOA exhibit greater mediolateral and anterior-posterior sway, increased sway length and area, and higher sway velocity compared to controls without KOA, specifically in the eyes open condition (Hassan et al., 2001; Tarigan et al., 2009; Taglietti et al., 2017). The preoperative HEP in this study resulted in an improvement in postural stability in women with severe KOA, as evidenced by a reduction in COP sway length during standing on a foam surface with eyes open, suggesting that the 8-week program may be sufficient to enhance balance under unstable conditions. The observed improvement in postural stability may be attributed to increased lower limb muscle strength post-HEP, as the unilateral PT of the involved limb was negatively associated with COP sway radius under unstable conditions. Previously, it was also found that muscle strength and postural stability are closely associated, and impairments in both should be addressed in the prevention and rehabilitation of KOA (Zeng et al., 2022). In addition to muscle weakness and dysfunction, the intensity of knee pain can contribute to reduced ability to maintain postural stability, leading to increased postural sway (Hassan et al., 2001).

The interaction between pain and postural stability was also supported by this study as knee pain was found to be positively associated with COP sway radius, suggesting that higher pain levels may be linked to poorer postural stability. Therefore, the modest improvement in postural stability observed in this study may be partly explained by the persistence of knee pain in the KOA group post-HEP and suggests that incorporating targeted pain reduction strategies into preoperative HEPs may enhance their effectiveness in addressing postural stability impairments. As previous studies have shown therapeutic exercises to be beneficial for improving balance in women with KOA, and support inclusion of balance training in this patient population (Tarigan et al., 2009; Silva et al., 2012), it is possible that a longer intervention period may have been necessary to observe greater effect as the prevalent joint damage and persistent pain are common in severe stage of KOA. Also, as evidence suggests that individuals with milder KOA respond more favourably to exercise than those with severe KOA (Abdel-Fattah et al., 2023), implementing the HEP at an earlier stage might produce more pronounced improvements in postural stability.

This is further supported by the KOA group participants self-reported fear of falling remaining unchanged after the HEP, suggesting that their perception of balance did not change remarkably following the exercise program. However, as MFES score ≥8 indicates no fear of falling (Hill et al., 1996), the KOA group's scores – 7.9 pre-HEP and 8.2 post-HEP – indicate a low perceived fear of falling before HEP and no fear of falling after HEP. This suggests that an 8-week HEP, including balance exercises, can possibly influence the perceived fear of falling in women with severe KOA.

Consistent with previous findings (Orr, 2010; Hoops et al., 2012), the present study identified leg extensor muscle strength to be associated with perceived fear of falling and postural stability in women with severe KOA. More broadly, multiple functional impairments, including muscle weakness, reduced knee proprioception, limited range of motion, and gait disturbances, are known contributors to balance deficits and the risk of falling (Hoops et al., 2012; Rosadi et al., 2022) and should be targeted in rehabilitation.

6.2. The effect of HEP on gait characteristics

KOA patients often demonstrate shortened stance phase and exhibit altered gait biomechanics, e.g. reduced KEM (Ogaya et al., 2017). In this study, following the 8-week HEP, the KEM during the loading response phase of gait in the KOA group increased by 37.8% and GRF by 19.4%, with KEM reaching levels comparable to the CON group. This increase suggests enhanced gait efficiency and movement control against gravity during the stance phase (Key, 2010). This is further supported by a reduction in GRF asymmetry between limbs in the KOA group after the intervention. Zeng et al. (2022) has reported asymmetrical biomechanics of the lower limbs is in individuals with unilateral KOA (Zeng et al., 2022), therefore the reduced GRF difference between limbs in the KOA group of the present study indicates improved gait symmetry.

Improved gait may be linked to increased leg extensor muscle strength, which was found to affect gait parameters in this study, including KEM. This association was noted only pre-HEP, suggesting that the HEP may have altered the underlying relationship and as the muscle strength improved, the gait efficiency increased, and the association between the characteristics was no longer relevant.

This highlights the importance of resistance exercises in home-based prehabilitation programs for women with KOA, contributing to improved gait function and overall functional mobility. Ogaya et al. (2017) also reported a significant association between quadriceps muscle strength and KEM during the early stance phase of gait. Therefore, exercise therapy and home-based exercise programs aimed at improving gait in women with severe KOA should include targeted strengthening exercises for lower limbs.

In this study, knee flexion AROM in the KOA group was also positively associated with spatiotemporal characteristics of gait such as step length, stride length, and mean gait velocity and negatively associated with step width. However, despite improvements in knee flexion AROM following the HEP, spatiotemporal characteristics remained unchanged. As patients with severe KOA often live with osteoarthritis for over 13 years before undergoing TKA and have structural changes in the knee joint that can limit functional recovery (O'Reilly et al., 1999; Losina et al., 2015), it is possible that an 8-week HEP may be insufficient to meaningfully affect these aspects of gait at later stages of the disease. Furthermore, gait − particularly during loading phase − is affected by knee extension deficits, which are common in severe KOA (Harato et al., 2014). This is noteworthy, as in the current study HEP did not produce significant improvements in knee joint extension AROM. The persistent knee extension deficits in the KOA group could have contributed to the spatiotemporal characteristics remaining unchanged, although, no significant associations were observed between gait and knee joint extension AROM.

Following the HEP, KEM of the involved limb reached levels comparable to the CON group. Other gait characteristics were and remained better in the CON group both before and after the HEP. Further research with longer or earlier intervention periods and larger samples are needed to better understand the effects of preoperative HEPs on gait characteristics in individuals with severe KOA.

6.3. The effect of HEP on bioelectrical activity of thigh muscles and leg extensor muscle strength

Previous studies have shown that individuals with KOA exhibit altered quadriceps muscle activity, generate less force during voluntary isometric contractions, and demonstrate a lower quadriceps strength-to-mass ratio compared to age- and gender-matched controls without KOA (Hassan et al., 2001). They experience reduction in both isokinetic and isometric PT of the knee flexors and extensors (Tan et al., 1995). It has been consistently shown that exercise improves isokinetic and isometric knee strength while reducing pain and physical limitations in individuals with osteoarthritis (Henrotin et al., 2012). Therefore, leg extensor muscle strength – especially when assessed under closed-chain conditions – is considered a strong indicator of functional capacity in patients with KOA (Swank et al., 2011). Based on this, the present study investigated lower limb extensor muscle strength and bioelectrical activity in closed-chain settings.

Individuals with KOA exhibit dysfunction in both knee extensors and flexors compared to individuals without KOA (Adegoke et al., 2007), possibly due to muscle atrophy, impaired voluntary muscle activation, and increased co-activation of muscles (Busse et al., 2006). This is particularly evident in women (Smith et al., 2020). However, the bioelectrical muscle activity patterns during sit-to-stand tasks, particularly during the eccentric phase, are largely unexplored. In the present study, the positive effect of the 8-week HEP was found in the bioelectrical activity of the thigh muscles during the FTSST. A post-HEP decrease in antagonist muscle activity and an increase in agonist muscle activity during both the concentric (sit-to-stand) and eccentric (stand-to-sit) phases indicated reduced co-contraction and improved motor control. However, the KOA group participants demonstrated higher activity of both knee extensor and flexor muscles during the FTSST in comparison to controls. This indicates poorer motor control during a sit-to-stand movement in women with severe KOA compared to peers without KOA, reflecting less efficiency and a compensatory increase in muscle activity, highlighting the need to specifically address such transitions in this patient group. Alterations in muscle bioelectrical activity have been associated with reduced muscle strength (Bouchouras et al., 2015), which may explain the abovementioned differences between the groups in this study.

Additionally, the knee extensor muscles bioelectrical activity appeared to be more affected by KOA than knee flexor muscles activity. Extensor muscles are typically more impacted by KOA and linked to other functional impairments (Jegu et al., 2014; Patterson et al., 2023), which may explain why the knee extensors showed less improvement and a greater difference compared to the CON group. However, since there was a pre-HEP difference in KOA group participants knee flexors bioelectrical activity compared to the CON group, targeting both muscle groups is essential in prehabilitation programs. In addition to the differences observed between the extensor and flexor muscles activity, an asymmetry between the involved and uninvolved limb was noted in the KOA group pre-HEP. Following the intervention, this asymmetry was reduced, indicating a more balanced use of both lower limbs and, consequently, improvements in movement patterns, which was supported by findings from gait and postural stability assessments.

Notably, greater improvements were observed during the transition from sitting to standing (concentric phase) compared to standing to sitting (eccentric phase), possibly due to increased leg extensor muscle strength and reduced antagonist (knee flexor) muscles co-contraction post-HEP. Increased co-contraction is often associated with compensatory strategies to avoid or reduce pain, maintain function, and compensate for functional limitations such as decreased muscle strength (Bouchouras et al., 2015). Thus, the reduced co-contraction combined with enhanced muscle strength likely enabled more efficient movement patterns with less effort. In the current study, this was further reflected in the faster FTSST times post-HEP, indicating that the 8-week HEP effectively enhanced lower limb strength and functional mobility. The improved bioelectrical activity of both knee extensors and flexors and increased leg extensor muscle strength may have contributed to the clinically meaningful improvement observed in the FTSST time in the KOA group participants.

The isometric leg extensor muscle strength increased significantly after the 8-week HEP – unilateral and bilateral PT by 50% and 27.3%, respectively; the unilateral and bilateral PT-to-BW ratio by 52% and 25.9%, respectively. Additionally, the RPTD improved by 40%. In addition to that, the strength asymmetry between the limbs decreased: before HEP, the involved limb demonstrated 42.6% lower PT than the uninvolved limb, which was reduced to 24.4% post-HEP. A similar pattern was observed in the PT-to-BW ratio, with a 42.7% difference pre-HEP, improving to a 21.7% deficit post-HEP. As individuals with unilateral KOA typically exhibit difference in muscle strength between limbs (Zeng et al., 2022), the findings of the present study suggest that the preoperative 8-week HEP led to faster and greater strength production with less strength asymmetry in women with severe KOA before TKA. This aligns with the findings from Swank et al. (2011), who reported that a 4- to 8-week prehabilitation exercise program significantly improved strength in the involved limb and reduced strength asymmetry. Similarly, Jan et al. (2008) found that individuals with KOA who completed an 8-week strength training program significant improved knee extensor muscle torque (Jan et al., 2008).

Greater muscle strength is known to alleviate symptoms and slow the progression of KOA (Segal et al., 2012). Notably, despite mentionable post-HEP improvement in leg extensor muscle strength, participants in the KOA group demonstrated less leg extensor muscle strength and higher perceived knee pain than controls. Functional deficits in the lower limbs, particularly in leg extensor strength, are strongly associated with symptoms such as pain, altered gait, impaired postural stability, and decreased functional mobility in KOA patients (Hassan et al., 2001; Zeng et al., 2021; Kiritbhai et al., 2023; Patterson et al., 2023; Bae et al., 2024). In the present study, a higher level of knee pain was also associated with lower extensor muscle strength pre-HEP. However, this association was no longer evident as strength increased following the HEP. Although the 8-week preoperative HEP appeared effective in improving muscle strength, it did not alleviate knee pain measured with VAS. This aligns with previous evidence that exercise therapy has more profound effect on functional outcomes than on pain in KOA patients (Henrotin et al., 2012). The minimal reduction in knee pain may reflect the extent of joint damage in this advanced stage of the disease, suggesting that in severe KOA, functional limitations due to pain may persist even after implementation of exercise interventions.

However, since knee pain is a primary symptom of KOA and often a focal point of rehabilitation (Kolasinski et al., 2020; Brophy & Fillingham, 2022), the negative association between muscle strength and knee pain in this study reflects the potential of targeted HEPs to address functional impairment in this patient population. Muscle strength is strongly related to various aspects of KOA, including symptoms, motor function, physical performance (Tarigan et al., 2009; Zeng et al., 2021; Patterson et al., 2023; Kiritbhai et al., 2023; Bae et al., 2024;), and disease progression (de Zwart et al., 2018). Previous study demonstrated that higher preoperative muscle strength is also associated with better postoperative outcomes and recovery in KOA patients (Swank et al., 2011). Therefore, preoperative exercise programs, including HEPs, should include resistance training as a component of prehabilitation for patients with severe KOA, emphasizing the essential role of HEP in rehabilitation across all stages of the disease.

6.4. The effect of HEP on functional outcomes and perceived health status

A primary goal of rehabilitation programs is to enhance the ability to perform functional tasks with greater ease and with fewer or milder symptoms. In the current study, the KOA group participants demonstrated mentionable improvements in perceived pain, functional ability, and overall health status after the HEP. This was reflected by improvement in WOMAC scores: pain decreased by 20%, functional limitations by 17%, and total perceived health status improved by 18%. Therefore, it can be concluded that a HEP is an effective alternative to outpatient rehabilitation for improving perceived health status, daily functional performance, and quality of life in women with severe KOA awaiting TKA. In a study by Baker et al. (2001), home-based strength training was shown to significantly improve muscle strength, physical function, and quality of life, as well as reduce pain levels in patients with KOA, as evidenced by improvements in WOMAC scores post-intervention (Baker et al., 2001). Similarly to the results of the present study, O'Reilly et al. (1999) found that a HEP led to 22.5% and 17.4% improvements in WOMAC pain and function scores, partly attributing this to increased muscle strength. This association is further confirmed by the findings of the present study and those of Kim et al. (2020), who found that leg extensor muscle strength was linked to perceived health status, as measured by WOMAC total and subscale scores. In the current study, an increase in muscle strength after the HEP was accompanied by improvements in WOMAC scores, reflecting better perceived health status related to KOA. This perceived improvement may have also influenced decision-making, as 5 out of 18 participants (27.8%) in the KOA group chose to postpone their scheduled TKA, indicating that the HEP could have had an impact on their outlook regarding surgical intervention.

In the present study, positive associations were also observed between WOMAC scores and knee joint flexion AROM, further supporting the importance of including AROM exercises alongside leg extensor strengthening in preoperative HEPs for women with severe KOA. Before HEP, both muscle strength and knee flexion AROM were positively associated with perceived health status; however, this link was no longer evident after HEP, suggesting that improvements in isometric leg extensor muscle strength and knee joint flexion AROM in the KOA group may have contributed to the enhanced perceived health status. However, the negative association between pain and WOMAC sub-scores and total index persisted post-HEP, likely because the KOA group participants did not demonstrate significant decrease in the VAS pain score. This underscores the need for HEPs to also incorporate targeted strategies specifically designed to manage pain. As knee pain is one of the most prominent and debilitating symptoms in KOA (Kolasinski et al., 2020; Brophy & Fillingham, 2022), these findings emphasize the importance of further research aimed at optimizing HEPs to better address pain management.

This is further supported by the observed changes in knee AROM, with knee flexion improving by 9.7% post-HEP. However, it is important to note that the improvement was limited to knee flexion. KOA group participants demonstrated persistent knee joint extension deficit, suggesting that the HEP was more effective at improving knee flexion than extension motion. Hilfiker et al. (2015) identified knee pain as a key factor influencing knee AROM in patients with KOA. In the present study, the VAS pain score was also negatively associated with knee AROM flexion prior to the HEP. Since previous research has linked knee pain to limitations in both knee flexion and extension (Hilfiker et al., 2015), the limited improvement in VAS score may have contributed to the persistence of the knee extension deficit observed post-HEP in the KOA group.

The WOMAC results from this study suggest that the 8-week HEP can enhance patients' perceptions of their health status and ability to perform daily activities. One common everyday challenge for individuals with KOA is standing up from a seated position – a task that a healthy adult performs an average of 45 timed per day (Bohannon, 2015). KOA patients likely perform this task less frequently, contributing to their muscle weakness and functional decline. Therefore, rehabilitation programs focusing on muscle strength and balance may be particularly effective in improving this movement (Bohannon, 2015). In the current study, the preoperative 8-week HEP improved functional lower limb muscle strength and dynamic balance in the KOA group, as indicated by a 16.6%, reduction in FTSST time. Following the HEP, participants in the KOA group completed the test 2.6 seconds faster, surpassing the minimal clinically important difference of 1.9 to 2.3 seconds (Meretta et al., 2006; Kaszyński et al., 2022). Notably, the KOA group's FTSST time improved from 15.5 s to 12.9 s, approaching the reference value of 11.4 seconds for adults aged 60–69 years (Bohannon, 2006a). The CON group consistently completed the FTSST test approximately two times faster than the KOA group before and after the HEP, with an average time of 6.7 seconds. A FTSST time of 8.8 seconds or more is associated with increased fall risk in older adults (Amano & Tamari, 2022), highlighting the functional limitations observed in the KOA group participants, likely influenced by osteoarthritis-related structural changes. Similarly, the TUG test result also reflected impaired functional mobility in the KOA group, with a test time of 9 s both pre-HEP and post-HEP, which was slower than the CON group's 5.9 s and the age-based reference value of 8.1 s (Bohannon, 2006b).

6.5. Strengths, limitations and future perspectives of the study

This study addressed the understudied yet clinically important phase of prehabilitation by evaluating the effects of a preoperative HEP in women with severe KOA scheduled for TKA. Novel aspects include assessing thigh muscle bioelectrical activity during concentric and eccentric phases of the sit-to-stand movement to provide a broader view of muscle function and analysing the gait during loading response – a critical phase of gait for individuals with impaired lower limb function when the leg first bears weight. The results suggest that preoperative HEPs can improve several aspects of motor function and functional mobility in women with severe KOA, including leg muscle strength, bioelectrical activity during sit-to-stand movement, and knee flexion AROM. Although the effects on postural stability and gait function were more modest, they are encouraging. These functional gains are further supported by improvements in perceived health status.

The potential limitations of this study include a small sample size which limits the generalizability of the results to the broader KOA and healthy population. However, the study included consistent data collection by the same research team members, ensuring consistency and reliability; a comprehensive assessment combining objective and subjective measures to provide a complex, patient-centred perspective; and a focus on women, who are disproportionately affected by KOA. The simple, cost-effective HEP required no specialized equipment, making it accessible and usable for clinical application. Functional and perceived health improvements were observed after just 8 weeks of HEP, showing the potential of short-term preoperative home interventions in women with severe KOA. Therefore, the study offers insights into observed trends and potential benefits of the intervention, supporting the need for larger-scale follow-up studies.

Participants in the KOA group had significantly higher BMI than the control, and it has been reported that higher body mass in women with KOA is associated with lower physical activity (Raud et al., 2020). Therefore, to minimise the effect of anthropometric differences, the data were normalised to body mass and body height. Also, the actual applied force during exercises was not objectively measured, however standardised resistance bands were used. No postoperative outcome data of this study were published due to a limited number of participants willing or able to participate post-TKA. Postoperative data would have been valuable in evaluating whether preoperative improvements translated into sustained postoperative benefits. Although gait analysis is best understood by considering multiple joints, this study focused on clarifying knee kinematics in the early stance phase. Lastly, although physical activity was tracked in training diaries, this data was not analysed. However, osteoarthritis patients are physically less active due to their symptoms (Raud et al., 2020).

The outcomes of this study support the inclusion of structured home-based resistance and mobility training programs in prehabilitation protocols of individuals with severe KOA. The findings of this study offer valuable practical implications for healthcare professionals – particularly physiotherapists and orthopaedic surgeons – and may assist in planning preoperative rehabilitation and selecting treatment strategies. The results of the study also benefit patients with KOA by highlighting the potential of HEPs as an alternative therapy to improve functional outcomes before TKA. Considering the need for prevention and treatment in patients with osteoarthritis and with the prevalence of KOA and TKA surgeries rising, more research on preoperative HEPs is needed to analyse their complex effect. Preoperative HEPs should be considered a possible and practical alternative or addition to outpatient exercise therapy for patients with severe KOA scheduled for TKA, potentially supporting preoperative status, post-operative recovery and long-term outcomes. Further research is needed to assess the long-term effect of preoperative HEPs after TKA. With advances in technology and its growing use in rehabilitation, future studies should also explore exergames, virtual reality or mixed reality possibilities as a complementary tool in KOA home-based prehabilitation, as it has shown promising results, yet evidence is still limited (Wei et al., 2024).

7. CONCLUSIONS

1. An 8-week preoperative home exercise program (HEP) enhances postural stability on unstable surface but does not affect fear of falling in women with severe knee osteoarthritis (KOA) scheduled for primary unilateral total knee arthroplasty (TKA).
2. Ground reaction force and knee extensor moment during the gait loading response increase, whereas spatiotemporal gait parameters remain unchanged after an 8-week preoperative HEP in women with severe KOA scheduled for primary unilateral TKA.
3. An 8-week HEP reduces co-contraction and asymmetry of bioelectrical activity of knee extensors and flexors during sit-to-stand movement in women with severe KOA scheduled for primary unilateral TKA.
4. Leg extensor muscle strength and knee flexion range of motion increases, strength asymmetry between limbs decreases, functional mobility improves, and perceived health status enhances after an 8-week HEP in women with severe KOA scheduled for primary unilateral TKA.
5. Before the exercise program, postural stability, gait function, and perceived health status are associated with leg extensor muscle strength, knee pain, and active knee flexion range of motion, though most of these associations are not evident after the 8-week HEP.
6. Following the 8-week HEP, knee extensor moment during the loading response of gait and the bioelectrical activity of the knee flexors during sit-to-stand movement in women with severe KOA scheduled for primary unilateral TKA does not differ compared to peers without KOA, although other functional outcomes remain poorer.

8. REFERENCES

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APPENDIX

Appendix. Preoperative 8-week home exercise program for patients with severe knee joint osteoarthritis scheduled for total knee arthroplasty.

Exercises	Progression	Description
Ex. 1 Stationary walking	1–8 weeks	Walk at a medium pace, hands move along the sides. 1 repetition of 3 min.
Ex. 2 High knee walking	1–8 weeks	While walking, do knee lifts as high as possible. Walk at a medium pace, hands move along the sides. 1 repetition of 1 min.
Ex. 3 Hip adductors strength		While sitting, place a ball between your knees and press the ball with the knees for 2–3 s and then relax.
	1–2 weeks	1 set of 16 repetitions at low resistance.
	3–4 weeks	2 sets of 16 repetitions at low resistance.
	5–6 weeks	1 set of 16 repetitions at moderate resistance.
	7–8 weeks	2 sets of 16 repetitions at moderate resistance.
Ex. 4 Hip abductors strength		While sitting, tie a rubber band around your knees and push your knees outward against the rubber band. Exertion held for 2–3 s and then relaxed.
	1–2 weeks	1 set of 10–16 repetitions at low resistance.
	3–4 weeks	2 sets of 10–16 repetitions at low resistance.
	5–6 weeks	1 set of 10–16 repetitions at moderate resistance.
	7–8 weeks	2 sets of 10–16 repetitions at moderate resistance.
Ex. 5 Knee extensor strength		While sitting, straighten the lower limb against the rubber band placed under the foot. Hold for 2–3 s, relax. Do the exercise alternately.
	1–2 weeks	1 set of 16 repetitions at low resistance.
	3–4 weeks	2 sets of 16 repetitions at low resistance.
	5–6 weeks	1 set of 16 repetitions at moderate resistance.
	7–8 weeks	2 sets of 16 repetitions at moderate resistance.
Ex. 6 Leg extensor strength, balance		Sit on the chair. Make 3 “attempts” to get up from the chair (without getting up). Get up on the 4th time.
	1–2 weeks	1 set of 12 repetitions at low resistance.
	3–4 weeks	2 sets of 12 repetitions at low resistance.
	5–6 weeks	1 set of 12 repetitions at moderate resistance.
	7–8 weeks	2 sets of 12 repetitions at moderate resistance.

Exercises	Progression	Description
Ex. 7 Dorsiflexor strength, balance		Stand behind the chair, hold the backrest. Rise on your toes and hold the position for 2–3 s.
	1–2 weeks	1 set of 20 repetitions at low resistance.
	3–4 weeks	2 sets of 20 repetitions at low resistance.
	5–6 weeks	1 set of 20 repetitions at moderate resistance.
	7–8 weeks	2 sets of 20 repetitions at moderate resistance.
Ex. 8 Plantarflexor strength, balance		Stand behind the chair, hold the backrest. Stand on your heels and hold the position for 2–3 s.
	1–2 weeks	1 set of 20 repetitions at low resistance.
	3–4 weeks	2 sets of 20 repetitions at low resistance.
	5–6 weeks	1 set of 20 repetitions at moderate resistance.
	7–8 weeks	2 sets of 20 repetitions at moderate resistance.
Ex. 9 Gluteus maximus strength, balance		Stand behind the chair, hold the backrest. Move your straight leg to the side. Toes pointed forward. Do the exercise alternately.
	1–2 weeks	1 set of 20 repetitions at low resistance.
	3–4 weeks	2 sets of 20 repetitions at low resistance.
	5–6 weeks	1 set of 20 repetitions at moderate resistance.
	7–8 weeks	2 sets of 20 repetitions at moderate resistance.
Ex. 10 Knee flexors and extensors strength		Stand behind the chair, hold the backrest. Start squatting until you reach a semi-squat. Make sure your knees do not go over the line of your toes.
	1–2 weeks	1–2 sets of 16 repetitions at low resistance.
	3–4 weeks	1–2 sets of 16 repetitions at low resistance.
	5–6 weeks	2–3 sets of 16 repetitions at moderate resistance.
	7–8 weeks	2–3 sets of 16 repetitions at moderate resistance.
Ex. 11 Balance		Stand on one foot as long as possible. Repeat with other side.
	1–2 weeks	1 set of 8 repetitions at low resistance.
	3–4 weeks	2 sets of 8 repetitions at low resistance.
	5–6 weeks	1 set of 8 repetitions at moderate resistance.
	7–8 weeks	2 sets of 8 repetitions at moderate resistance.
Ex. 12 Hamstring stretch		While sitting, extend one leg forward and place it on the heel. Bend forward to feel the stretch in the back of your thigh. Perform the exercise alternately and with maximally tolerable knee extension. Hold for 6–8 s.
	1–2 weeks	1 set of 16 repetitions at low resistance.
	3–4 weeks	2 sets of 16 repetitions at low resistance.
	5–6 weeks	1 set of 16 repetitions at moderate resistance.
	7–8 weeks	2 sets of 16 repetitions at moderate resistance.

Exercises	Progression	Description
Ex. 13 Hamstring stretch		While sitting, extend one leg forward and place it on the heel. Bend forward to feel the stretch in the back of your thigh. Perform the exercise alternately and with maximally tolerable knee extension and ankle dorsiflexion. Hold for 6–8 s.
	1–8 weeks	1 set of 6 repetitions.
Ex. 14 Gastroc-nemius stretch		While sitting, extend one leg forward and place it on the heel. Pull your toes towards you as much as possible. Perform the exercise alternately and with maximally tolerable ankle dorsiflexion. Hold for 6–8 s.
	1–8 weeks	1 set with 6 repetitions.
Ex. 15 Relaxation		Rest lying down.
	1–8 weeks	Breathe deeply and relax.

SUMMARY IN ESTONIAN

Preoperatiivse koduse harjutusprogrammi mõju motoorsele funktsioonile raskekujulise põlveliigese osteoartroosiga naistel, kes on suunatud täielikule endoproteesimisele

KOA avaldub mitmete sümptomite ja funktsionaalsete piirangutena, mis oluliselt langetavad elukvaliteeti (Lespasio et al., 2017; Kiritbhai et al., 2023). Põlveliigese osteoartroosi (ingl k *knee osteoarthritis*, KOA) esinemissagedus suureneb koos rahvastiku vananemise ja ülekaalulisuse leviku kasvuga (Lespasio et al., 2017; Kiritbhai et al., 2023). KOA esineb sagedamini naistel kui meestel (Ma et al., 2022). Samuti on naistel haiguse sümptomid väljendunumad (Tonelli et al., 2011; Klug et al., 2021) ja neile teostatakse suurema tõenäosusega täielik põlveliigese endoproteesimine (ingl k *total knee arthroplasty*, TKA). Kirurgilist sekkumist, sh TKA-d, rakendatakse KOA hilistes faasides (Zeng et al., 2021). TKA teostamine on kulukas (Ackerman et al., 2019) ning patsiendile koormav, mistõttu on vaja leida viise soodustamaks operatsiooni maksimaalset efektiivsust kui ka leida võimalusi selle potentsiaalseks edasi lükkamiseks.

Preoperatiivsetest konservatiivsetest ravivõimalustest on taastusravi, sh terapeutilised harjutused üks esmaseid valikuid (Hurley, 2003; Bennel & Hinman, 2011). On leitud, et terapeutilised harjutused aitavad leevendada KOA-ga patsientide sümptomeid ja parandada funktsiooni. Lihasjõudu suurendavad harjutused, tasakaaluharjutused ja venitusharjutused on olulised nii lühiajalises perspektiivis kui ka osana preoperatiivsest taastusravist (Swank et al., 2011). Mitmed uuringud on keskendunud peamiselt KOA varajastele staadiumitele või postoperatiivsetele sekkumistele. Vähem on uuritud raskekujulise KOA-ga patsiente ja preoperatiivsete koduste harjutusprogrammide (ingl k *home exercise program*, HEP) mõju. HEP võib olla alternatiiviks, kui ambulatoorse ravi võimalused on piiratud, seetõttu on täiendavad uuringud preoperatiivse HEP-i mõju hindamiseks raskekujulise KOA-ga naiste sümptomitele ja motoorsele funktsioonile aktuaalsed.

Uurimistöö eesmärk ja ülesanded

Uurimistöö eesmärgiks oli välja selgitada preoperatiivse HEP-i mõju TKA-le suunatud raskekujulise KOA-ga naiste motoorsele funktsioonile, funktsionaalsele mobiilsusele ja tajutud terviseseisundile, ning võrrelda tulemusi samaealiste naistega, kellel ei esine KOA-d.

Eesmärgi saavutamiseks püstitati järgmised uurimisülesanded:

1. Hinnata posturaalse stabiilsuse ja tajutud kukkumishirmu näitajate muutusi pärast 8-nädalase preoperatiivse HEP-i sooritamist raskekujulise KOA-ga naistel.

2. Analüüsida kõnni ruumilis-ajaliste ja toefaasi kineetiliste näitajate muutusi pärast 8-nädalase preoperatiivse HEP-i sooritamist raskekujulise KOA-ga naistel.
3. Hinnata muutusi reielihaste bioelektrilises aktiivsuses istest püstitõusul ja alajäsemete sirutajalihaste jõu näitajates pärast 8-nädalase preoperatiivse HEP-i sooritamist raskekujulise KOA-ga naistel.
4. Analüüsida muutusi põlveliigese funktsiooni, funktsionaalse mobiilsuse ja tajutud terviseseisundi näitajates pärast 8-nädalase preoperatiivse HEP-i sooritamist raskekujulise KOA-ga naistel.
5. Hinnata korrelatiivseid seoseid motoorse funktsiooni, funktsionaalse mobiilsuse ja tajutud terviseseisundi näitajate vahel raskekujulise KOA-ga naistel.
6. Võrrelda raskekujulise KOA-ga naiste motoorse funktsiooni ja funktsionaalse mobiilsuse näitajaid enne ja pärast 8-nädalase preoperatiivse HEP-i sooritamist samaealiste naistega, kellel ei esine KOA-d.

Uuritavad ja metoodika

Käesolev uurimistöö põhines longitudinaalsel sekkumisuuringul, milles hinnati 8-nädalase preoperatiivse HEP-i mõju. Objektiivsed ja subjektiivsed mõõtmised viidi läbi raskekujulise KOA-ga naistel (vanus 61,8±1,6 aastat; n=18; KOA grupp) kahel korral ning samaealistel tervetel naistel (n=10; CON grupp) ühel korral. KOA grupi uuritavad sooritasid preoperatiivset HEP-i igapäevaselt 8 nädala jooksul.

KOA grupi uuritavad värvati ortopeediakirurgi poolt Tartu Ülikooli Kliinikumi TKA-le suunatud naiste hulgast, kellel oli primaarne KOA (3 ja 4 aste Kellgren & Lawrence järgi (1957)), suunamine esmasele ühepoolsele TKA-le, võimekus kõndida ilma abivahendita, hea nägemisvõime prillidega või ilma ning valmisolek regulaarselt kodus harjutusi sooritada. CON grupi moodustasid samaealised naised, kellel radioloogilisel uuringul ei tuvastatud KOA-d ja kes ei osalenud regulaarselt treeningutel. Mõlemas grupis olid väljaarvamiskriteeriumiteks alajäsemete traumad ja luumurrud viimase 12 kuu jooksul, operatsioonid alajäseme piirkonnas ning hindamismeetodite rakendamist või saadud tulemusi mõjutada võivate süsteemsete haiguste esinemine. Kõik osalejad andsid kirjaliku nõusoleku uuringus vabatahtlikult osalemiseks ning nende õigused olid kaitstud. Käesolev uurimistöö oli osa suuremast projektist ja uuring oli kooskõlastatud Tartu Ülikooli inimuuringute eetika komiteega (protokollid 218/T-16 ja 153/9). Uuring oli registreeritud ClinicalTrials.gov veebilehel (registreerimisnumber NCT02881463).

Esmalt hinnati uuritavate tajutud põlvevalu visuaal-analoogskaalaga (VAS), kukkumishirmu *The Modified Falls Efficiency Scale* skaalaga (MFES) ning KOA-ga seotud terviseseisundit The *Western Ontario and McMaster Universities Osteoarthritis Index*iga (WOMAC). Seejärel mõõdeti antropomeetrilisi näitajaid ning viidi läbi funktsionaalsed mõõtmised – põlveliigese aktiivne liikuvusulatus ja *Timed Up and Go* test. Uuriti posturaalse stabiilsuse näitajaid eri tasapindadel seistes, reielihaste bioelektrilise aktiivsuse näitajaid *Five Times Sit-to-Stand* testi kontsentrilise ja ekstsentrilise faasi ajal, 3D kõnnianalüüsi ruumilis-ajalisi ja kinemaatilisi näitajaid toefaasi ajal ning alajäseme sirutajalihaste isomeetrilisi jõunäitajaid.

Alghindamise lõpus õpetas füsioterapeut igale KOA grupi uuritavatele individuaalselt HEP-i harjutuste korrektset sooritamist. HEP koosnes 15 alajäsemete lihasjõudu, tasakaalu, koordinatsiooni ja liigesliikuvust parandavast harjutusest, mille intensiivsust suurendati vastavalt treeningnädalale (*Appendix*). Kõik KOA grupi vaatlusalused said kolmest kummilindist koosneva komplekti, treeningpäeviku ja harjutuste korrektset sooritamist toetava illustreeritud detailsete kirjelduste ja juhistega prinditud harjutusprogrammi. Tagasiside saamiseks ning HEP-i regulaarse ja korrektse sooritamise soodustamiseks helistas füsioterapeut KOA grupi uuritavatele iganädalaselt.

Järeldused

1. Pärast 8-nädalast preoperatiivset HEP-i paraneb TKA-le suunatud raskekujulise KOA-ga naistel keha tasakaal ebastabiilsel pinnal seistes, kuid tajutud kukkumishirm ei muutu.
2. TKA-le suunatud raskekujulise KOA-ga naistel paraneb pärast 8-nädalast preoperatiivset HEP-i kõnni amortisatsioonifaasi toereaktsioon ja põlveliigese sirutusmoment, kuid kõnni ruumilis-ajalisi näitajad ei muutu.
3. 8-nädalase preoperatiivse HEP-i tulemusena väheneb TKA-le suunatud raskekujulise KOA-ga naistel põlveliigese sirutaja- ja painutajalihaste ko-kontraktsioon ja aktivatsiooni asümmeetria istest püsti tõusul.
4. TKA-le suunatud raskekujulise KOA-ga naistel suurenevad pärast 8-nädalast preoperatiivset HEP-i alajäsemete sirutajalihaste jõud, põlveliigese aktiivne fleksioonliikuvus ja funktsionaalne mobiilsus, väheneb jäsemetevaheline jõu asümmeetria ning paraneb tajutud terviseseisund.
5. Posturaalse stabiilsuse ja kõnni näitajad ning tajutud terviseseisund olid seotud alajäsemete sirutajalihaste jõu, põlveliigese valu ja põlveliigese aktiivse fleksioonliikuvusega. Enamik seoseid taandusid pärast sekkumist.
6. Pärast preoperatiivset HEP-i ei ilmnenud KOA-ga naistel erinevusi kõnni amortisatsioonifaasi põlveliigese sirutusmomendi ning reielihaste bioelektrilise aktiivsuse näitajates võrreldes samaealiste naistega. Teiste uuritud näitajate puhul olid eakaaslaste tulemused paremad.

Uuringu tugevused ja piirangud ning praktiline väärtus

Käesolev uuring käsitles väheuuritud, kuid kliiniliselt olulist preoperatiivset taastusravi faasi, hinnates preoperatiivse HEP-i mõju raskekujulise KOA-ga naistele, kes on suunatud TKA-le. Preoperatiivset rehabilitatsiooni on uuritud vähem kui postoperatiivset, seega annab käesolev töö lisaväärtust olemasolevale infole. Uudseteks aspektideks olid reielihaste bioelektrilise aktiivsuse hindamine istumast püsti tõusmise kontsentrilises ja ekstsentrilises faasis ning kõnni amortisatsiooni faasi analüüsimine. Uuringu tugevuseks oli, et mõõtmisi teostasid samad uurimisgrupi liikmed, mis tagas mõõtmiste ühtsuse, ning et hindamine kaasas nii objektiivseid kui ka subjektiivseid mõõdikuid. Uuringus osalesid naispatsiendid, kellel esineb KOA arvestatavalt sagedamini kui meestel. HEP sooritamine ei vajanud keerukaid vahendeid, muutes selle kergesti teostavaks ja praktikas rakendatavaks. Funktsionaalset ja tajutud terviseseisundi paranemist täheldati juba kaheksanädalase sekkumise järgselt, toonitades lühiajaliste preoperatiivsete sekkumiste potentsiaali. Uuringu potentsiaalseteks piiranguteks olid väike valim, mis võib piirata tulemuste üldistamist; HEP-i jõuharjutustel kasutatud vastupanujõudu ei mõõdetud, kuid kasutusel olid standardsed kummilindid; KOA grupi märkimisväärselt suurem kehamassiindeks võrreldes CON grupiga; ja operatsioonijärgsete tulemuste mittekaasamine, mis oleks võimaldanud saada ülevaadet HEP-i pikaajalisest potentsiaalsest toimest.

Käesoleva uurimistöö tulemused pakuvad praktilisi suuniseid tervishoiutöötajatele, sealhulgas füsioterapeutidele ja ortopeedidele, kui ka KOA-ga patsientidele. Preoperatiivset HEP-i saab raskekujulise KOA-ga patsientide ravis käsitleda arvestatava sekkumisena – nii alternatiivina kui ka lisana ambulatoorsele füsioteraapiale, eriti olukordades, kus teenuse kättesaadavus on raskendatud. Käesoleva töö tulemused viitavad sellele, et preoperatiivsete harjutuste sooritamine kodukeskkonnas on tõhus ning parandab oluliselt raskekujulise KOA-ga naiste motoorset funktsiooni ja tajutud terviseseisundit. Arvestades osteoartroosiga patsientide ennetus- ja ravivajadust ning KOA ja TKA levimuse kasvu, on vaja alternatiivseid preoperatiivseid sekkumisi, sh HEP-i, ka edaspidi uurida. Vaja on täiendavaid suuremahulisi uuringuid, et hinnata preoperatiivsete HEP-de pikaajalist toimet nii enne kui ka pärast TKA-d. Tulevased uuringud võiksid preoperatiivse koduse taastusravi uurimisel rakendada ka tehnoloogilisi ravimeetodeid ja nende alternatiive, nagu interaktiivsed videomängud, virtuaalne ja liitreaalsus, mis on näidanud positiivseid tulemusi, kuid mille kohane teadusinfo on vähene (Wei et al., 2024).

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PUBLICATIONS

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