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Nordic Walking and Functional Outcomes After Total Knee Arthroplasty

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ABSTRACT

Awareness regarding the impact of prehabilitation and postoperative rehabilitation on recovery after total knee arthroplasty (TKA) has steadily increased in recent years, with growing evidence highlighting their essential role in improving functional outcomes, mobility, and quality of life. Contemporary medical guidelines emphasize not only the importance of structured rehabilitation programs but also the need for individualized therapeutic approaches that consider patients as unique units requiring tailored interventions rather than homogeneous groups. Despite the well-established benefits of conventional rehabilitation strategies, many patients continue to experience limitations in muscle strength, gait performance, and physical activity levels following surgery. In this context, there is an increasing interest in identifying safe, accessible, and effective forms of physical activity that can complement standard rehabilitation protocols. This narrative review aims to examine current evidence on Nordic walking as a potential intervention supporting functional recovery in patients after TKA. Nordic walking, characterized by the use of poles engaging both upper and lower extremities, has been shown to improve cardiovascular fitness, muscular activation, balance, and overall functional capacity in various populations. Its low-impact nature and potential to enhance gait mechanics and stability suggest that it may be particularly suitable for individuals recovering from knee arthroplasty. Although direct evidence in TKA populations remains limited, the physiological and biomechanical benefits observed in other groups indicate that Nordic walking may represent a promising adjunct to rehabilitation programs. Further research is warranted to determine its effectiveness and to establish evidence-based recommendations for its integration into postoperative care.

Background. Total knee arthroplasty is one of the most effective surgical interventions for advanced knee osteoarthritis, leading to substantial pain reduction and improved joint function. However, many patients continue to experience limitations in gait performance, muscle strength, and overall physical activity following surgery. Postoperative rehabilitation therefore plays a critical role in restoring functional mobility and quality of life. Walking-based exercise programs are commonly recommended after TKA, and emerging evidence suggests that Nordic walking—a form of walking using poles that engages both upper and lower body musculature—may offer additional functional benefits.

Objective. The aim of this narrative review is to examine current evidence regarding the potential role of Nordic walking in improving functional outcomes after total knee arthroplasty.

Methods. A narrative literature review was conducted using PubMed, PEDro, and Scopus identified English-language studies related to rehabilitation after TKA, gait recovery, functional performance, return to physical activity, and Nordic walking interventions. The included literature consisted of randomized controlled trials, cohort studies, and systematic reviews addressing postoperative rehabilitation strategies, walking-based training programs, and Nordic walking in adult and older populations.

Results. The reviewed literature indicates that structured exercise and walking-based rehabilitation programs significantly improve gait speed, quadriceps strength, range of motion, and overall functional performance after TKA. Studies also demonstrate that walking training enhances recovery of functional ambulation and quality of life. Evidence from Nordic walking research shows improvements in cardiovascular fitness, muscle activation, functional capacity, and balance in older adults and clinical populations. The use of poles promotes greater engagement of upper body musculature, increases stride length, and may support more stable gait patterns. Although direct research on Nordic walking specifically after TKA remains limited, its biomechanical and physiological characteristics suggest it may be a safe and effective adjunct to postoperative rehabilitation programs.

Conclusion. Nordic walking represents a promising low-impact physical activity that may support functional recovery after total knee arthroplasty by enhancing gait mechanics, muscular engagement, and overall physical performance. Further controlled clinical studies are needed to evaluate its specific effects in patients following TKA and to determine optimal training protocols within postoperative rehabilitation.

Keywords: total knee arthroplasty, Nordic walking, rehabilitation, gait recovery, functional outcomes, physical activity

Contents

1. Introduction

Osteoarthritis of the knee is one of the most common degenerative joint diseases and a major cause of pain, disability, and reduced quality of life worldwide. As the disease progresses, conservative treatment options such as pharmacotherapy, physiotherapy, and lifestyle modifications may become insufficient to control symptoms and restore functional mobility. In advanced stages of knee osteoarthritis, total knee arthroplasty (TKA) is considered one of the most effective surgical interventions for reducing pain and improving joint function. Numerous studies have demonstrated that TKA significantly improves patient-reported outcomes, mobility, and overall quality of life in individuals with severe knee degeneration (Mizner et al., 2005; Moffet et al., 2004).

Despite the success of TKA in alleviating pain and restoring joint alignment, many patients continue to experience functional limitations following surgery. Persistent deficits in quadriceps strength, gait speed, and physical performance are commonly reported even months after the procedure (Mizner et al., 2005; Petterson & Stevens-Lapsley, 2009). Early postoperative muscle weakness, particularly of the quadriceps, has been identified as a key factor influencing functional recovery after knee replacement (Mizner et al., 2005). These impairments can negatively affect walking ability, balance, and the ability to perform activities

of daily living. As a result, structured rehabilitation programs play a crucial role in restoring mobility and maximizing the functional benefits of surgery.

Postoperative physiotherapy typically focuses on improving joint range of motion, muscle strength, and gait mechanics. Systematic reviews indicate that exercise-based rehabilitation programs significantly enhance physical function and mobility after total knee replacement (Artz et al., 2015; Pozzi et al., 2013). In addition, rehabilitation strategies that include progressive strengthening and functional training have been shown to improve clinical outcomes and accelerate the recovery process (Petterson et al., 2009). Intensive rehabilitation programs may further enhance functional ability and quality of life during the postoperative period (Moffet et al., 2004). Therefore, identifying effective and safe forms of physical activity that support functional recovery after TKA remains an important area of research.

Walking-based training is one of the most commonly recommended forms of physical activity during rehabilitation after knee arthroplasty. Regular walking contributes to improvements in gait performance, cardiovascular fitness, and overall physical function. Studies have shown that walking programs can enhance muscle strength and quality of life in individuals who have undergone TKA (Hsu et al., 2023). Moreover, functional walking tests such as the six-minute walk test have been shown to be reliable indicators of postoperative mobility and recovery of functional ambulation (Ko et al., 2013). Improvements in gait speed have also been associated with better functional outcomes and increased independence in daily activities after knee replacement surgery (Pua et al., 2017).

In addition to traditional walking programs, alternative forms of walking exercise have gained increasing attention in rehabilitation and health promotion. Nordic walking, which involves walking with specially designed poles, is a whole-body activity that engages both upper and lower extremity musculature. This form of exercise increases energy expenditure and may enhance cardiovascular and musculoskeletal benefits compared with regular walking. A systematic review by Tschentscher et al. (2013) demonstrated that Nordic walking improves physical fitness, aerobic capacity, and overall health outcomes in various populations. Randomized controlled trials have also reported improvements in functional capacity and physical performance among older adults participating in Nordic walking programs (Parkatti et al., 2012).

Biomechanical studies suggest that Nordic walking modifies gait patterns by increasing stride length and promoting more active upper body involvement during locomotion (Hansen et al., 2008). The use of poles may improve stability and balance, which could be particularly beneficial for individuals recovering from orthopedic surgery. Because Nordic walking is

considered a low-impact form of exercise, it may represent a safe and accessible activity for patients after joint replacement. Furthermore, current recommendations indicate that several low-impact sports activities can be safely resumed within months following total knee arthroplasty, highlighting the importance of promoting safe physical activity after surgery (Thaler et al., 2021; Witjes et al., 2016).

Although walking-based rehabilitation has been widely investigated in patients following TKA, research specifically addressing the role of Nordic walking in this population remains limited. Given the potential biomechanical and physiological advantages of Nordic walking, it may represent a promising adjunct to conventional rehabilitation programs aimed at improving functional outcomes after knee arthroplasty.

Therefore, the purpose of this narrative review is to examine current evidence regarding rehabilitation strategies, walking-based training, and Nordic walking, with particular emphasis on their potential role in improving functional outcomes after total knee arthroplasty.

2. Research materials and methods

A narrative literature review was conducted using PubMed, PEDro, and Scopus identified English-language studies related to rehabilitation after TKA, gait recovery, functional performance, return to physical activity, and Nordic walking interventions. The included literature consisted of randomized controlled trials, cohort studies, and systematic reviews addressing postoperative rehabilitation strategies, walking-based training programs, and Nordic walking in adult and older populations.

3. Research results

3.1. Functional Recovery After Total Knee Arthroplasty

Total knee arthroplasty (TKA) is widely recognized as an effective surgical intervention for patients with advanced knee osteoarthritis, leading to substantial improvements in pain relief, joint stability, and overall quality of life. Nevertheless, despite successful surgical outcomes, many patients experience persistent functional limitations in the postoperative period. Recovery after TKA is a complex and multifactorial process influenced by muscle strength, joint mobility, neuromuscular control, and patient participation in rehabilitation programs.

One of the most frequently reported impairments following TKA is a significant reduction in quadriceps muscle strength. Early postoperative weakness of the quadriceps has been identified as a critical factor limiting functional performance. Research has shown that

quadriceps strength can decrease substantially immediately after surgery due to muscle atrophy and deficits in voluntary muscle activation (Mizner et al., 2005). This early decline in muscle strength can delay functional recovery and affect a patient's ability to perform essential activities such as walking, climbing stairs, or rising from a chair. Moreover, persistent quadriceps weakness has been associated with slower improvements in functional mobility during the postoperative rehabilitation period (Mizner et al., 2005).

Functional recovery after TKA is also strongly related to the effectiveness of postoperative rehabilitation. Progressive strengthening exercises and structured physiotherapy interventions have been shown to significantly improve functional outcomes. A randomized clinical trial conducted by Petterson et al. (2009) demonstrated that progressive strengthening programs targeting the lower extremity muscles can lead to measurable improvements in functional performance after TKA. These improvements include enhanced walking ability, greater independence in daily activities, and improved patient-reported functional outcomes.

In addition to muscle strength, joint range of motion plays an important role in postoperative recovery. Adequate knee flexion and extension are necessary for performing daily activities such as walking, sitting, and stair negotiation. Rehabilitation programs that focus on restoring joint mobility and functional movement patterns have been shown to significantly improve early postoperative recovery (Artz et al., 2015; Pozzi et al., 2013). Systematic reviews examining exercise-based rehabilitation after knee arthroplasty indicate that structured physical activity interventions can improve both short-term and long-term functional outcomes.

Functional recovery after TKA can also be enhanced through intensive rehabilitation programs. Evidence from randomized controlled trials suggests that patients participating in intensive rehabilitation protocols experience greater improvements in functional ability and quality of life compared with those receiving standard rehabilitation programs (Moffet et al., 2004). Such programs often include a combination of strengthening exercises, gait training, and functional mobility tasks aimed at restoring independence and improving physical performance.

Despite these improvements, some patients continue to demonstrate deficits in functional performance even months after surgery. Studies comparing postoperative patients with healthy individuals have reported persistent impairments in muscle strength, walking performance, and physical activity levels (Bade et al., 2010). These findings highlight the importance of long-term rehabilitation strategies aimed at improving physical function and preventing postoperative functional decline.

Furthermore, early rehabilitation interventions that specifically target neuromuscular activation may accelerate recovery. Neuromuscular electrical stimulation has been shown to

improve quadriceps muscle strength and functional outcomes when incorporated into early postoperative rehabilitation programs (Stevens-Lapsley et al., 2012). Such interventions may help address early postoperative muscle inhibition and support more rapid restoration of functional capacity.

Overall, the literature indicates that although TKA effectively reduces pain and improves joint mechanics, optimal functional recovery requires comprehensive rehabilitation strategies focusing on muscle strength, joint mobility, and functional movement training. Addressing these factors is essential for restoring mobility, improving gait performance, and enabling patients to return to an active lifestyle after surgery.

3.2. Rehabilitation Strategies After Total Knee Arthroplasty

Rehabilitation is a fundamental component of postoperative management following total knee arthroplasty (TKA), as it directly influences the recovery of joint function, muscle strength, and overall mobility. The primary goals of rehabilitation include restoring knee range of motion, improving muscle strength—particularly of the quadriceps—and facilitating the return to functional activities such as walking, stair climbing, and activities of daily living. Early initiation of rehabilitation programs has been widely recommended to prevent joint stiffness, reduce postoperative complications, and accelerate functional recovery.

Exercise-based physiotherapy remains the cornerstone of rehabilitation after TKA. Structured exercise programs focusing on strengthening, flexibility, and functional training have been shown to significantly improve postoperative outcomes. A systematic review and meta-analysis by Artz et al. (2015) demonstrated that physiotherapy exercise programs following total knee replacement are associated with improved physical function and mobility. Similarly, Pozzi et al. (2013) reported that therapeutic exercise interventions, including resistance training and functional task practice, are effective in enhancing postoperative recovery and physical performance.

Strength training plays a particularly important role in rehabilitation after TKA due to the substantial decline in quadriceps strength observed after surgery. Progressive resistance exercises targeting the lower extremity muscles have been shown to improve functional capacity and walking ability. Evidence suggests that strengthening programs that progressively increase load and intensity can lead to significant improvements in functional outcomes compared with standard rehabilitation approaches (Petterson et al., 2009). In addition, high-

intensity preoperative and postoperative training programs may enhance early recovery by improving baseline muscle strength and neuromuscular control (Calatayud et al., 2017).

Another key component of postoperative rehabilitation is the restoration of knee joint range of motion. Limited knee flexion or extension can negatively affect gait mechanics and daily functional activities. Rehabilitation protocols therefore often include stretching exercises, passive and active mobilization techniques, and functional movement training to improve joint mobility. Clinical studies have demonstrated that rehabilitation programs incorporating range-of-motion exercises contribute to improved knee function and greater independence in daily activities (Hiyama et al., 2016).

Different rehabilitation settings and delivery models have also been investigated in the literature. Both home-based and hospital-based rehabilitation programs have been shown to be effective in improving postoperative outcomes. A comparative study by López-Liria et al. (2015) reported that structured home-based rehabilitation programs can achieve functional improvements comparable to those observed in hospital-based physiotherapy programs. Similarly, systematic reviews indicate that supervised rehabilitation and well-designed home exercise programs can both contribute to improved postoperative recovery, provided that patients adhere to the prescribed exercises (Papalia et al., 2013).

Neuromuscular interventions may further enhance rehabilitation outcomes. Techniques such as neuromuscular electrical stimulation have been shown to improve quadriceps activation and muscle strength during the early postoperative phase. Stevens-Lapsley et al. (2012) demonstrated that the addition of neuromuscular electrical stimulation to standard rehabilitation protocols resulted in significantly greater improvements in quadriceps strength and functional performance after TKA.

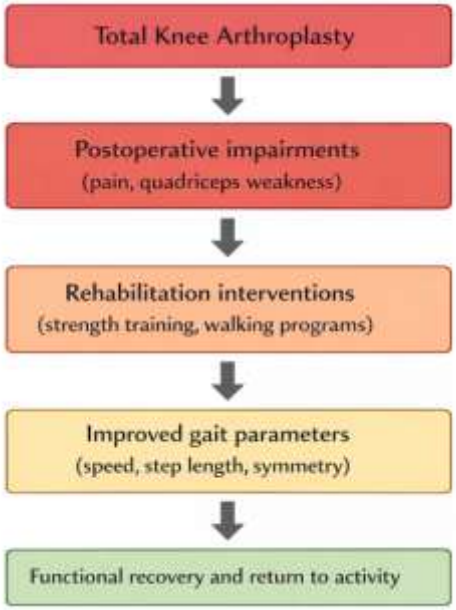
In addition to strength and mobility training, rehabilitation programs frequently include functional exercises designed to improve balance, coordination, and gait performance. Such exercises aim to facilitate the safe return to everyday activities and reduce the risk of falls. Systematic reviews examining physiotherapy interventions following TKA highlight the importance of comprehensive rehabilitation programs that combine strengthening, mobility training, and functional task practice (Henderson et al., 2018).

Overall, the available evidence indicates that rehabilitation strategies after total knee arthroplasty should be multifaceted and individualized. Programs that combine progressive strengthening exercises, mobility training, neuromuscular activation techniques, and functional task practice appear to be the most effective in promoting optimal recovery. Continued research

is necessary to determine the most effective rehabilitation protocols and to identify strategies that maximize functional outcomes in patients following TKA.

3.3. Walking Ability and Gait Recovery After TKA

Recovery of walking ability is one of the principal goals of rehabilitation after total knee arthroplasty (TKA), as gait performance is closely linked to independence, participation in daily activities, and overall quality of life. Although TKA effectively reduces joint pain and improves mechanical alignment, normalization of gait is often delayed, and many patients continue to demonstrate altered walking patterns for weeks or months after surgery. These gait disturbances may include reduced walking speed, shorter step length, asymmetrical limb loading, and impaired balance control, all of which can limit functional mobility in the postoperative period. Figure 1. presents visualization of recovery milestones.



Source: author's elaboration using canva.com based on reviewed literature

Figure. 1. Post TKA recovery milestones.

One of the most frequently reported indicators of gait recovery after TKA is walking speed. Gait speed is considered a clinically meaningful measure because it reflects both lower-limb function and the ability to move safely and efficiently in everyday environments. Pua et al. showed that recovery of gait speed after TKA is influenced by multiple factors, including muscle strength, pain, and functional capacity, emphasizing that gait restoration is not solely dependent on surgical success but also on the effectiveness of postoperative rehabilitation (Pua

et al., 2017). Slower gait speed after surgery has been associated with lower functional independence and reduced confidence in mobility.

Walking performance after TKA is also commonly assessed using standardized functional tests. Among them, the six-minute walk test has been shown to be a valuable and practical measure of postoperative ambulatory function. Ko et al. demonstrated that the six-minute walk test is an excellent predictor of functional ambulation after total knee arthroplasty, supporting its usefulness in both clinical evaluation and rehabilitation monitoring (Ko et al., 2013). Similarly, the 50-foot walk test and chair stand test have been reported as reliable tools for assessing mobility and functional performance in patients after TKA (Unver et al., 2015). These measures provide insight into a patient's walking efficiency, endurance, and readiness to resume daily activities.

Structured walking-based interventions appear to play an important role in gait recovery after TKA. Hsu et al. reported that a supervised 24-week walking training program improved knee muscle strength and quality of life in older women after TKA, suggesting that regular walking exercise may contribute not only to improved physical performance but also to broader aspects of postoperative recovery (Hsu et al., 2023). Such findings support the inclusion of progressive walking programs as part of rehabilitation protocols, particularly in patients who require additional support in restoring endurance and confidence during ambulation.

Physical activity in general may also positively influence gait restoration after knee arthroplasty. Taniguchi et al. found that greater levels of physical activity were associated with improved gait outcomes after TKA, indicating that patients who remain more active after surgery may experience better functional recovery (Taniguchi et al., 2016). This relationship is clinically important because it suggests that promoting habitual movement and walking behavior beyond formal physiotherapy sessions may enhance long-term functional gains.

Gait recovery is strongly influenced by muscle performance, especially quadriceps function. Persistent quadriceps weakness after TKA may contribute to reduced walking speed, altered knee motion during stance, and compensatory strategies that affect overall movement efficiency. Because of this, interventions that improve lower-limb strength can indirectly enhance walking ability. Group-based exercise programs have also been shown to improve range of motion, muscle strength, and functional ability during the acute phase after TKA, all of which are closely related to gait restoration (Hiyama et al., 2016). These findings indicate that gait recovery should be understood as part of a broader process of functional rehabilitation rather than an isolated outcome.

Despite significant postoperative improvements, gait after TKA often does not fully return to the level observed in healthy adults. Residual asymmetries in walking mechanics and deficits in endurance may persist even after standard rehabilitation. This highlights the need for rehabilitation strategies that not only reduce pain and restore joint mobility but also specifically target gait quality, walking endurance, and movement symmetry. Walking-based rehabilitation should therefore include not only general ambulation practice, but also interventions aimed at improving step pattern, lower-limb loading, balance, and confidence in movement.

Overall, the available literature suggests that walking ability and gait recovery after TKA are essential determinants of successful postoperative outcomes (table 1.). Recovery of gait is influenced by strength, physical activity level, and participation in structured rehabilitation. Functional walking tests are useful for monitoring progress, while supervised walking interventions may improve both physical function and quality of life. These findings provide an important rationale for considering additional gait-oriented activities, such as Nordic walking, in the later stages of postoperative rehabilitation.

Table 1. Studies Examining Walking Ability and Gait Recovery After Total Knee Arthroplasty

Study	**Study design**	**Participants**	**Intervention / Measurement**	**Main findings**
Ko et al., 2013	Observational study	Patients after TKA	Six-minute walk test	Strong predictor of functional ambulation after TKA
Pua et al., 2017	Longitudinal study	Patients after TKA	Gait speed analysis	Gait speed associated with better functional recovery
Hsu et al., 2023	Retrospective cohort study	Older women after TKA	24-week supervised walking program	Improved knee muscle strength

				and quality of life
Taniguchi et al., 2016	Observational study	Patients after TKA	Assessment of physical activity levels	Higher activity levels associated with improved gait outcomes
Unver et al., 2015	Reliability study	Patients after TKA	50-foot walk test and chair stand test	Reliable tools for assessing mobility and functional performance
Hiyama et al., 2016	Controlled clinical trial	Patients after TKA	Group-based exercise program	Improved range of motion, muscle strength and functional mobility

3.4. Return to Physical Activity After Total Knee Arthroplasty

Restoring the ability to participate in physical activity is one of the primary expectations of patients undergoing total knee arthroplasty (TKA). In addition to reducing pain and improving joint function, many individuals hope to return to recreational activities, exercise, and sports following surgery. As life expectancy increases and patients remain physically active later in life, the demand for joint replacement procedures among active individuals continues to rise. Consequently, understanding the extent to which patients can safely resume physical activity after TKA has become an important topic in orthopedic and rehabilitation research.

Several studies have demonstrated that physical activity levels generally increase after TKA compared with the preoperative period. Vogel et al. reported that total joint arthroplasty significantly improves mobility and allows many patients to resume recreational physical

activities that were previously limited by pain and joint dysfunction. However, the type and intensity of physical activity performed after surgery often differ from preoperative levels, with patients typically favoring low-impact activities that place less stress on the prosthetic joint (Vogel et al., 2011). These activities commonly include walking, cycling, swimming, and low-impact fitness exercises.

Systematic reviews examining sports participation after knee arthroplasty suggest that many patients can return to recreational physical activity following surgery. Witjes et al. conducted a systematic review and meta-analysis investigating return to sports after total and unicondylar knee arthroplasty. Their findings indicated that a large proportion of patients successfully resume sports participation, particularly low-impact activities. The authors also noted that patients who were physically active before surgery were more likely to return to similar levels of activity afterward (Witjes et al., 2016).

In addition to individual motivation and preoperative activity levels, medical recommendations play a crucial role in determining the types of activities considered safe after TKA. Current orthopedic guidelines generally encourage participation in low-impact physical activities while advising caution with high-impact sports that may increase the risk of implant wear or mechanical complications. A consensus statement by the European Knee Associates identified several activities that can be safely performed after TKA, including walking, hiking, cycling, swimming, and Nordic walking. These activities are typically recommended because they involve relatively low joint loading while still providing important cardiovascular and musculoskeletal benefits (Thaler et al., 2021).

Participation in physical activity after TKA has also been associated with improved functional outcomes and overall well-being. Konings et al. reported that knee arthroplasty positively influences sports participation and activity levels, with many patients experiencing increased confidence in mobility and improved physical function after surgery (Konings et al., 2020). Engaging in regular physical activity can contribute to improved cardiovascular health, muscle strength, and psychological well-being, all of which are important factors in long-term postoperative recovery.

Despite these positive findings, not all patients return to their previous activity levels following TKA. Several barriers may limit postoperative physical activity, including persistent muscle weakness, fear of damaging the prosthesis, lack of confidence in joint stability, and insufficient rehabilitation support. Early postoperative limitations in strength and gait performance may also delay the return to more demanding physical activities. Therefore,

appropriate rehabilitation strategies and patient education are essential to facilitate safe and gradual reintroduction of physical activity.

Historical research also provides insight into long-term participation in sports after knee replacement. Bradbury et al. found that many patients were able to resume recreational sports after TKA, although participation rates varied depending on the intensity of the activity and individual patient characteristics (Bradbury et al., 1998). These findings suggest that while complete return to high-impact sports may not always be feasible, many individuals can achieve meaningful levels of physical activity following surgery.

Overall, the available literature indicates that total knee arthroplasty can enable patients to return to a physically active lifestyle, particularly when low-impact activities are emphasized. Encouraging safe forms of physical activity is important for maintaining functional capacity, promoting cardiovascular health, and improving quality of life after surgery. In this context, walking-based exercises and other low-impact activities may represent particularly suitable forms of postoperative physical activity. These findings also support the potential inclusion of activities such as Nordic walking in rehabilitation and long-term exercise programs for individuals following TKA.

3.5. Nordic Walking and Its Effects on Functional Capacity

Nordic walking (NW) is a form of physical activity that involves walking with specially designed poles, engaging both the upper and lower extremities during locomotion. Originally developed as an off-season training method for cross-country skiers, Nordic walking has gained increasing attention as a therapeutic exercise modality in rehabilitation and health promotion. Compared with regular walking, Nordic walking activates a larger number of muscle groups, increases energy expenditure, and may provide additional biomechanical and physiological benefits while maintaining a relatively low mechanical load on the lower extremity joints.

Several studies have demonstrated that Nordic walking can improve functional capacity, cardiovascular fitness, and muscular endurance in various populations. A systematic review conducted by Tschentscher et al. reported that Nordic walking significantly improves aerobic capacity, exercise tolerance, and overall physical fitness across a range of age groups and clinical populations (Tschentscher et al., 2013). The authors highlighted that Nordic walking provides greater energy expenditure than normal walking at the same speed while maintaining a comparable level of perceived exertion, making it a suitable form of exercise for individuals with reduced physical fitness. Nordic walking may also improve functional performance and

mobility in older adults. In a randomized controlled trial, Parkatti et al. demonstrated that a structured Nordic walking program significantly improved functional capacity and physical performance in older individuals compared with baseline measures (Parkatti et al., 2012). Participants who engage in regular Nordic walking showed improvements in walking endurance, balance, and overall physical activity levels. These findings suggest that Nordic walking may be particularly beneficial for populations experiencing mobility limitations or decreased physical fitness.

From a biomechanical perspective, Nordic walking alters gait patterns and muscle activation during locomotion. Hansen et al. investigated the biomechanical effects of Nordic walking and found that the use of poles changes walking mechanics by increasing stride length and promoting greater involvement of upper-body musculature (Hansen et al., 2008). Although Nordic walking does not necessarily reduce knee joint loading compared with regular walking, it redistributes muscular work across a larger number of muscle groups. This redistribution of mechanical demand may contribute to improved movement efficiency and stability during walking.

In addition to musculoskeletal benefits, Nordic walking has been shown to positively influence psychological well-being and quality of life in clinical populations. Passos-Monteiro et al. demonstrated that Nordic walking training improved quality of life, cognitive function, and depressive symptoms in individuals with Parkinson's disease, indicating that the benefits of this form of exercise may extend beyond purely physical outcomes (Passos-Monteiro et al., 2020). These findings highlight the broader therapeutic potential of Nordic walking as part of multidisciplinary rehabilitation programs.

Recent systematic reviews have further supported the health benefits associated with Nordic walking. Liu et al. reported that Nordic walking interventions can improve cardiorespiratory fitness, muscular strength, and overall health status in adult populations (Liu et al., 2022). The authors concluded that Nordic walking represents a safe and accessible form of physical activity that can be incorporated into exercise programs aimed at improving general health and physical performance.

Because Nordic walking combines aerobic exercise with active engagement of the upper and lower extremities, it may offer advantages for individuals undergoing rehabilitation. The use of poles may enhance balance and stability during locomotion, potentially reducing the risk of falls while encouraging greater participation in physical activity. Furthermore, Nordic walking can be easily adapted to different levels of physical fitness and functional ability, making it suitable for older adults and patients recovering from musculoskeletal conditions.

Table 2. Comparison of Nordic Walking and Conventional Gait (based on Tschentscher et al., 2013; Hansen et al., 2008; Parkatti et al., 2012).

Parameter	**Conventional Gait**	**Nordic Walking**
Muscle activation	Lower body dominant	Upper + lower body
Energy expenditure	Moderate	Higher (+20–40%)
Cardiovascular demand	Moderate	Higher
Balance support	Limited	Enhanced (poles)
Joint loading	Low	Low–moderate
Stride length	Standard	Increased
Functional benefits	Basic mobility	Enhanced functional capacity

Overall, the available evidence indicates that Nordic walking can positively influence functional capacity, including improvements in cardiovascular fitness, muscular activation, walking endurance, and overall physical performance (table 2.). These characteristics suggest that Nordic walking may represent a valuable form of exercise within rehabilitation programs aimed at improving mobility and physical function. Although direct evidence specifically examining Nordic walking in patients after total knee arthroplasty remains limited, the physiological and biomechanical benefits observed in other populations suggest that this form of activity may have potential applications in postoperative rehabilitation.

3.6. Potential Role of Nordic Walking in Rehabilitation After TKA

Given the growing emphasis on restoring functional mobility and encouraging safe physical activity after total knee arthroplasty (TKA), identifying effective and accessible

exercise modalities is an important objective in postoperative rehabilitation. Nordic walking has emerged as a promising form of physical activity that may support functional recovery especially as an addition to conventional rehabilitation pathway due to its combination of aerobic exercise, muscular engagement, and relatively low mechanical impact on the lower extremity joints (Figure 2.).

One of the primary goals of rehabilitation following TKA is to restore walking ability and improve overall functional performance. Walking-based training has already been shown to contribute to improved muscle strength, endurance, and quality of life after knee replacement surgery (Hsu et al., 2023). Nordic walking may further enhance these benefits because it involves active participation of both the upper and lower body during locomotion. The use of poles engages muscles of the shoulders, arms, and trunk, increasing total body muscular activation compared with conventional walking. This increased muscle involvement may contribute to improved cardiovascular fitness and functional capacity.

Another potential advantage of Nordic walking in postoperative rehabilitation is its effect on balance and stability. Patients recovering from TKA often experience reduced confidence in walking and impaired balance during the early stages of recovery. The use of poles during Nordic walking may provide additional points of support, which can improve stability and reduce the fear of falling. Improved balance and stability may encourage patients to participate more actively in rehabilitation exercises and daily physical activity.

Nordic walking may also influence gait mechanics in ways that are beneficial for individuals recovering from knee surgery. Biomechanical studies have shown that Nordic walking modifies gait patterns by increasing stride length and promoting more symmetrical walking movements (Hansen et al., 2008). Improved stride length and walking rhythm may contribute to more efficient gait patterns, which are often altered after TKA due to pain, muscle weakness, and compensatory movement strategies. Enhancing gait mechanics is an important component of functional rehabilitation because efficient walking patterns can reduce fatigue and improve mobility during daily activities.

Another important aspect of postoperative rehabilitation is encouraging long-term adherence to physical activity. Many patients gradually reduce their participation in structured exercise programs once formal physiotherapy sessions are completed. Nordic walking may represent an attractive long-term exercise option because it is simple to perform, requires minimal equipment, and can be practiced in a variety of outdoor environments. Research has shown that Nordic walking can improve aerobic capacity, muscular endurance, and overall

physical fitness, making it a suitable activity for maintaining functional capacity over time (Tschentscher et al., 2013).

Source: author's elaboration using canva.com based on reviewed literature

Figure. 2. Rehabilitation pathway after TKA with the added benefits of Nordic Walking.

Furthermore, Nordic walking may provide psychosocial benefits that contribute to rehabilitation outcomes. Engaging in outdoor physical activity has been associated with improvements in mood, motivation, and perceived quality of life. Studies examining Nordic walking interventions in clinical populations have reported improvements not only in physical performance but also in psychological well-being and quality of life (Passos-Monteiro et al., 2020). These factors may play an important role in long-term adherence to exercise and continued engagement in physical activity after joint replacement surgery.

Although the potential benefits of Nordic walking in rehabilitation appear promising, direct evidence examining its effects specifically in patients after TKA remains limited. Most of the current evidence originates from studies involving older adults or individuals with

chronic conditions. Nevertheless, the physiological and biomechanical characteristics of Nordic walking suggest that it may represent a safe and effective adjunct to conventional rehabilitation programs following knee arthroplasty.

Future research should focus on controlled clinical trials investigating the effectiveness of Nordic walking in patients undergoing TKA rehabilitation. Such studies could evaluate outcomes including gait mechanics, muscle strength, functional mobility, and quality of life. Establishing evidence-based guidelines for the timing, intensity, and duration of Nordic walking programs may help clinicians incorporate this activity into postoperative rehabilitation protocols.

In summary, Nordic walking has several characteristics that may support functional recovery after total knee arthroplasty, including increased muscular engagement, improved balance, enhanced gait mechanics, and promotion of long-term physical activity. While additional research is needed to confirm its effectiveness in this specific patient population, Nordic walking represents a promising complementary exercise modality within comprehensive rehabilitation programs following TKA.

4. Discussion

The present narrative review examined the current literature regarding functional recovery after total knee arthroplasty (TKA), rehabilitation strategies, gait restoration, return to physical activity, and the potential role of Nordic walking as a complementary exercise modality in postoperative rehabilitation. The reviewed evidence suggests that although TKA is highly effective in reducing pain and improving joint function, many patients continue to experience deficits in muscle strength, walking ability, and overall physical performance following surgery. Consequently, appropriate rehabilitation strategies and long-term physical activity are essential for optimizing postoperative outcomes.

One of the most consistent findings across the literature is the presence of persistent muscle weakness following TKA, particularly involving the quadriceps muscle group. Quadriceps strength plays a crucial role in functional mobility, gait performance, and the ability to perform activities of daily living. Previous studies have demonstrated that significant reductions in quadriceps strength occur shortly after surgery due to both muscle atrophy and impaired voluntary muscle activation (Mizner et al., 2005). These deficits may persist for months after the procedure and are strongly associated with slower functional recovery.

Progressive strengthening interventions have therefore been identified as a key component of rehabilitation programs aimed at restoring functional capacity after TKA (Petterson et al., 2009).

Rehabilitation programs that incorporate structured exercise interventions have been shown to improve mobility, muscle strength, and functional performance in patients after knee replacement. Systematic reviews indicate that physiotherapy-based exercise programs contribute significantly to improved postoperative outcomes and may enhance both short-term and long-term recovery (Artz et al., 2015; Pozzi et al., 2013). In addition, rehabilitation strategies that combine strengthening exercises with functional movement training appear to be particularly effective in improving physical performance and restoring independence in daily activities.

Restoration of walking ability represents another critical component of postoperative recovery. Gait impairments are commonly observed after TKA and may include reduced walking speed, altered step length, and asymmetrical loading patterns. Studies investigating gait recovery have demonstrated that improvements in walking performance are closely related to muscle strength, physical activity levels, and participation in rehabilitation programs. Functional tests such as the six-minute walk test and the 50-foot walk test have been shown to provide reliable assessments of walking ability and postoperative mobility (Ko et al., 2013; Unver et al., 2015). Moreover, increased physical activity has been associated with improved gait outcomes and greater functional independence after TKA (Taniguchi et al., 2016; Pua et al., 2017).

Returning to physical activity is an important outcome following knee arthroplasty, as many patients expect to resume recreational activities after surgery. The literature indicates that a substantial proportion of patients successfully return to physical activity following TKA, particularly when engaging in low-impact activities such as walking, cycling, and swimming (Witjes et al., 2016; Vogel et al., 2011). Participation in regular physical activity after surgery has been associated with improved functional outcomes, enhanced cardiovascular health, and improved quality of life (Konings et al., 2020). Nevertheless, some patients remain hesitant to engage in physical activity due to concerns about implant safety or persistent functional limitations.

In this context, identifying safe and effective forms of exercise that support long-term mobility and physical activity is of considerable importance. Nordic walking may represent one such option. Compared with conventional walking, Nordic walking engages a greater number of muscle groups and increases overall energy expenditure while maintaining relatively low joint loading. Previous research has shown that Nordic walking improves aerobic capacity,

muscular endurance, and functional performance in various populations (Tschentscher et al., 2013). Randomized controlled trials have also demonstrated improvements in functional capacity and physical fitness among older adults participating in Nordic walking programs (Parkatti et al., 2012).

From a biomechanical perspective, Nordic walking alters gait mechanics by increasing stride length and promoting greater involvement of the upper body during locomotion (Hansen et al., 2008). These biomechanical changes may contribute to improved walking efficiency and stability, which could be particularly beneficial for individuals recovering from orthopedic surgery. In addition, the use of poles may enhance balance and confidence during walking, potentially reducing fear of falling and encouraging greater participation in physical activity.

Despite these potential advantages, the current evidence specifically examining Nordic walking in patients after TKA remains limited. Most existing studies have focused on healthy older adults or individuals with chronic conditions. Therefore, further research is needed to determine whether the benefits observed in other populations can be directly translated to patients undergoing knee arthroplasty rehabilitation. Future studies should investigate the optimal timing, intensity, and duration of Nordic walking interventions following surgery, as well as their effects on gait mechanics, muscle strength, and functional outcomes.

Overall, the available literature suggests that Nordic walking may represent a promising adjunct to conventional rehabilitation strategies following total knee arthroplasty. By combining aerobic exercise with whole-body muscular engagement and relatively low joint loading, Nordic walking has the potential to support gait recovery, improve functional capacity, and promote long-term adherence to physical activity. Further clinical trials are needed to establish evidence-based recommendations regarding the integration of Nordic walking into postoperative rehabilitation protocols for patients after TKA.

5. Conclusions

Total knee arthroplasty (TKA) is an effective surgical procedure for reducing pain and improving joint function in patients with advanced knee osteoarthritis. However, successful surgical outcomes do not automatically translate into full functional recovery. Many patients continue to experience deficits in muscle strength, gait performance, and overall physical activity levels during the postoperative period. Therefore, comprehensive rehabilitation programs and promotion of long-term physical activity remain essential components of postoperative care.

The literature reviewed in this study highlights the importance of structured rehabilitation strategies that include progressive strengthening, restoration of joint mobility, and gait training. Improvements in quadriceps strength, walking ability, and functional mobility have been consistently associated with better postoperative outcomes and increased independence in daily activities. Walking-based exercise programs have also been shown to support functional recovery and enhance quality of life after TKA.

Nordic walking represents a promising form of low-impact physical activity that may complement traditional rehabilitation approaches. Due to its engagement of both upper and lower extremities, Nordic walking may enhance cardiovascular fitness, improve muscular activation, and promote more efficient gait patterns. Additionally, the use of poles may provide greater stability during walking, which could increase patient confidence and encourage greater participation in physical activity.

Although the physiological and biomechanical characteristics of Nordic walking suggest potential benefits for individuals recovering from knee arthroplasty, current evidence specifically investigating its role in TKA rehabilitation remains limited. Most available studies have focused on other populations, such as healthy older adults or individuals with chronic conditions. Consequently, further research is required to evaluate the effectiveness and safety of Nordic walking interventions in patients following total knee arthroplasty.

Future studies should aim to determine optimal training protocols, including the timing of introduction, frequency, and intensity of Nordic walking programs during postoperative rehabilitation. Well-designed randomized controlled trials are particularly needed to assess the impact of Nordic walking on gait recovery, muscle strength, functional mobility, and long-term physical activity adherence in patients after TKA.

In conclusion, Nordic walking may represent a valuable adjunct to conventional rehabilitation strategies following total knee arthroplasty. By promoting safe and accessible physical activity, this form of exercise has the potential to support functional recovery and improve overall health outcomes in patients after knee replacement surgery.

Disclosure

Author Contributions

Conceptualization: [AC], [JBl]

Methodology: [JB], [MC],[KPa]

Check: [JB], [KPa]

Investigation: [MC], [EC], [KP]

Data curation: [EC], [AB], [KP]

Writing - rough preparation: [AC], [AB], [DS]

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The authors declare no conflict of interest

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