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Wearable and Non-wearable Technology Assisted Assessment and Rehabilitation approaches for Gait Improvement among the Patients with Knee Arthroplasty: A Systematic Review

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This article presents a relevant review of technological interventions used in gait analysis for post-operative knee surgery cases. Gait analysis plays a vital role in the early monitoring and rehabilitation of post-operative instances. The Gait analysis help with early diagnosis and physiotherapy interventions can produce significant results. Thus, reducing the overall cost of treatment and increasing the effect of administered treatment. In the modern era, physiotherapists use different sensors to monitor spatiotemporal parameters. These sensors help assist and enhance the administered physiotherapy. This review paper focuses on sensor-based technological interventions in gait analysis. It emphasizes that technology-assisted rehabilitation, notably sensor-based technologies, motion sensors, and motion analysis software, improves monitoring and functional mobility in knee arthroplasty. The systematic search yielded 272 studies, 11 added retrospectively via reference screening of included articles. Following title and abstract screening, we include 53 studies for full-text screening, and ultimately, 20 studies met the review's predetermined eligibility criteria. Two physiotherapists, 'SR' and 'AS,' conducted a thorough search using various electronic databases and screened the eligibility of titles and abstracts. This review included a total of twenty studies. We included all those studies associated with various technological interventions, outcome measures, and study populations. All relevant studies were categorized and tabulated based on the technologies used, the type of device used, and the outcome measure used to monitor and quantify Gait and other mobility impairments. This review paper provides a comprehensive overview of the applications of technology-based intervention to monitor and quantify mobility status using assisted gait analysis. There is moderate-quality evidence that technology-assisted rehabilitation, specifically sensor-based technology, motion sensors, and motion analysis software, results in a statistically significant improvement in monitoring and functional mobility in patients undergoing knee arthroplasty.

Keywords: Gait Analysis; Knee Arthroplasty; Spatiotemporal Parameters of Gait.

Osteoarthritis is a common and debilitating illness that places a significant and growing health burden on individuals, healthcare systems, and broader socioeconomic costs. Global population aging, obesity, and joint injuries, all of which are already burdensome conditions, are becoming more common, with estimates estimating that nearly 250 million people have already been afflicted. Primary osteoarthritis, commonly known as degenerative joint disease, is a significant source of disability

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worldwide. It's also known as "wear and tear" arthritis, "age-related arthritis," or "degenerative joint disease". Health professionals use the term arthritis to refer to joint inflammation. Arthritis is a catch-all term in the public healthcare sector for approximately 100 inflammatory disorders and ailments affecting the joints, the tissues around the joints, and other connected tissues. Because osteoarthritis is such an important topic, it is impossible to cover everything in one article; so, the current article will focus on Osteoarthritis of the Knee. The most prevalent degenerative arthritis is Knee osteoarthritis (KOA), characterized by synovium inflammation, loss of articular cartilage, subchondral bone weakening, and meniscus degeneration [1]. Such intra- and extra-articular alterations in the knee contribute to a loss of range of motion as well as increased joint stiffness and discomfort [2]. In the elderly, KOA is a more prevalent musculoskeletal problem [3]. It is the most prevalent joint disease in India, with a prevalence ranging from 22% to 39% [4]. KOA affects more women than males, but the prevalence increases considerably as one gets older [5]. Almost half of women over 65 experience symptoms, and 70% have radiographic evidence. KOA is a significant source of mobility disability, especially in women. It also hurts the elderly's health and wellbeing [6]. Osteoarthritis of the knee affects all three parts of the knee joint, namely the medial, lateral, and patellofemoral joints. It frequently proceeds gradually over 10 to 15 years, affecting most daily duties. Previously assumed to be a "wear-and-tear" articular cartilage problem caused simply by aging and unrelated to inflammation. Although the pathogenesis of this illness is still under debate, it is an assumption that the osteoarthritis of the knee is multidimensional.

It is also considered that, in addition to inflammation and biochemical abnormalities, a mix of other variables contribute to knee osteoarthritis. These factors include a family history of illness, increasing age, diabetes, synovial membrane inflammation, joint shape, lower limb alignment, dysplasia, and inflammation caused by metabolic conditions. The diagnosis of knee osteoarthritis is made based on the patient's history and a physical examination. Though X-rays validate the physical examination findings, new high-resolution equipment helps resolve severe cases' intricacy. There are risk factors associated with the development of osteoarthritis of the knee that fall into two categories: non-modifiable (a genetic mutation makes someone more vulnerable to developing osteoarthritis of the knee) and intrinsic (in which someone has the abnormal natural shape of bone around the knee). However, the second category is the modifiable risk factor, including those factors (e.g., obesity) that various treatments can address. Typically, therapies focus on the second category, i.e., modifiable risk factors. Moreover, osteoarthritis patients choose to adopt surgical methods or pharmacological treatments such as intra-articular injections, braces and devices, physiotherapy, and suitable exercises.

Nonetheless, in the present day, Total knee Arthroplasty (TKA) is thought to be the most often performed surgical surgery in the orthopaedic field to reduce pain and improve functionality and the overall patient experience [7]. TKA is considered one of the most effective treatments for terminal knee osteoarthritis. It is also a potential treatment option for a wide range of other inherent medical disorders, including arthritis connected with inflammation, rupture, deformations induced by trauma, dysplasia, and deformities. At present, TKA is considered as one of the most popular therapies for severe osteoarthritis of the knee (OA); since its inception in the 1970s at the Medical Center for Special Surgical Intervention, TKA has improved dramatically over the previous 50 years. Because of the increasing prevalence of knee osteoarthritis, the need for TKA is growing at an alarming rate worldwide. Even though TKA is becoming increasingly popular worldwide, an intriguing estimate predicts that by 2030, the number of major TKA surgeries in the United States will have increased dramatically. Norway reported an upsurge in TKA procedures, with nearly 7,000 primary knee replacements performed in 2017 alone [8]. In the same year, the United States recorded nearly 1 million TKA procedures worldwide, with an average of 280 procedures performed per 100,000 of the total population [9].

TKA has seen tremendous growth during the last several decades. Cooperation among medical professionals and technologists made several advancements in creating prosthetics. Those ranged from the classic resurfaced prosthesis to the restricted prosthetics and meniscal carrying prosthetics [5] and just about everything else. TKA is accompanied by physiotherapy and an exercise rehabilitation program [10]. During a hospital stay, physiotherapy focuses on mobility and accomplishing functional goals related to hospital discharge [11]. Furthermore, post-operative physiotherapy support and case-by-case exercise regimens facilitate retraining and functional improvement [12]. With the rise in life expectancy, the expected increase in KOA and TKA surgery and pre and post TKA rehabilitation significantly burden the healthcare system [13]. The most crucial aspect of rehabilitation is resuming standard walking patterns following knee arthroplasty [14]. The gait analysis approach is another effective tool for collecting and analyzing quantitative and pattern-based data across time [15]. It remains an essential technology for several medical purposes, such as illness diagnosis and monitoring.

A person's Gait may be affected by various mental and physical disorders. Gait analysis has applications in sports, computer gaming, rehabilitation programs, clinical evaluation, monitoring, individual identification, simulation, and other fields. There are proven techniques for gait analysis that use several sensors, with accelerometers being among the most used. Generally, it is considered that the accelerometer sensors are much more user-friendly and far less intrusive. Human gait analysis is a recent occurrence in computer imaging, with numerous well-known applicability such as patient's monitoring. This tool detects anomalous behavior in clinically suspicious patients, such as difficulties with the walking pattern. The phrase "suspicious behavior" refers to evaluations of knee joints and every other disorder directly impacting patients' movement. Human gait analysis is essential in the health sector. However, variations in patient' clothing, watching angle, and transporting circumstances might harm system performance. Numerous deep learning algorithms, particularly those concentrating on optimized feature selections, have recently been suggested for this purpose; nonetheless, their accuracy is limited. The capacity to track Gait over time makes it simpler to detect persistent walking problems [16].

Furthermore, a system that can quantitatively evaluate Gait for patients who do not have access to motion analysis facilities, either because they reside in economically poor, rural, or undeveloped areas, opens new diagnostic and treatment options for clinicians and patients [17]. The measurement, quantification, and analysis of human movement are part of gait analysis [18]. It aids in determining the gait phase and kinematic analysis of linked gait events for musculoskeletal function assessment [19]. Therefore, gait analysis has been used in sports, rehabilitation, and health diagnostics. In biomedical engineering, gait analysis has been a fundamental and helpful tool for characterizing human locomotion [20].

Motion capture system using numerous cameras linked to ground reaction forces has been published by gait laboratories [21]. The described approach necessitates the development and upkeep of a high-budget laboratory [16]. To minimize total costs based on human observation, a somewhat less expensive Visual observation-based alternative is widespread, which requires more clinician interaction and delivers individual, sophisticated, and error-prone quantitative analysis [22]. Wearable motion sensors offer a low-cost out-of-laboratory technique that combines convenience and best attributes [23]. This article includes several ground-breaking experiments on developing and applying wearable sensor-based systems for gait analysis. It emphasizes the importance, usability, user-friendliness of gait analysis.

METHODOLOGY

Several studies and clinical trials on osteoarthritis (OA) have been published in the past years. This review is based on a systematic review of the literature from year 2010 to year 2021 with a subjective final selection of papers. Specifically, those papers are discussed to bring novel concepts relevant to clinical practice. More data has emerged indicating that OA is a severe disease with a growing global impact [24]. Waiting for new treatment modalities to arise, such as joint replacement, is a crucial alternative; new data on how long they may endure has been available [25]. The most effective treatment for knee osteoarthritis remains a hot topic. In postoperative infections, revisions, and persistent pain, definitive management supported total knee arthroplasty offers a superior prognosis [27]. Injectable medicines offer a highly promising potential of a safer and more efficient treatment option for people suffering from knee osteoarthritis [28]. Osteoarthritis of large joints of lower limb is a major cause of impaired functionality and discomfort in millions of people worldwide [30]. The best evidence supports exercise to improve pain, work, and quality of life [31]. Some physiotherapy approaches still need more evidence to be supported, and the National Institute for Health and Clinical Excellence does not endorse the use of acupuncture [32]. It has been proven that a single form of exercise program is more beneficial than various exercise programs [33]. External skin marker-based gait analysis is a competent tool for studying the kinematics and determining kinetic parameters for various TKA procedures [34]. This strategy necessitates data collection and proper analysis based on optimal algorithms. Furthermore, accurate findings require correct calibration [35]. Few fixed threshold values are employed, such as force plate calibration at 1080 Hz and the usage of optoelectronic cameras at 120 Hz frequency [36]. The Davis approach is generally accepted and used to place skin markers in TKA's gait research. Calibration necessitates static trials corresponding to specified body areas to achieve accurate measurement. As a result of fatigue or distraction, all acquired complicated datasets must be examined regularly to properly record walking tempo and a person's particular gait styles. These iterations should be repeated at a predetermined number of 3–5 gait cycles [37]. For determining the location of the joint center and the anatomical axes of total knee arthroplasty, related anthropometric measures are merged with data from a three-dimensional marker obtained during a static examination (to assure consistency of results) [38].

The study's kinetic data should be linked to body weight (BW) and the percentage of BW paired with the individual's height [39]. This method offers improved possibilities for gathering and correlating precise, trustworthy, accurate, and reproducible data to research biomechanical parameters presented on distinct TKAs [37]. In clinical practice, the entire process of determining a model for human Gait is either expensive or complex in terms of implementation. Inertial sensors combined with adaptive algorithms are used [40]. Analyzing inertial sensor signals with Artificial Intelligence (AI) algorithms has been a great way to perform an effective gait analysis [41]. However, more research is needed to improve and further standardize the application in a wide range of patients, as most studies identified in the literature involved healthy participants. So, the scenario-specific study is a must approach to finding an appropriate algorithm [42]. The proposed study sought to comprehend the relationship between gait speed and biomechanical factors. This study conducted a thorough review of the impacts of gait speed in a diverse group of healthy people, including children, young adults, and older adults, using data such as spatiotemporal characteristics, joint kinematics, joint kinetics, and ground reaction forces [43]. The Quality Index parameter was established to assess methodological consistency, covering 95 percent confidence intervals and normalized mean differences. The meta-analyses introduced a fixed/random effect model that evaluated statistical heterogeneity using the I2 index [44]. This systematic review aimed to assess and expand the evidence base supporting the clinical usefulness of gait analysis. As a result, we obtained clear data based on numerous assessing approaches used in conjunction with current evidence to confirm the clinical effectiveness of gait analysis, particularly at lower efficacy levels. However, models based on case studies are still necessary to provide accuracy and robustness at higher efficacy levels [45].

Motion capture technologies are routinely employed to assess human gait [46]. Traditionally, cameras capture two-dimensional (2D) video, which is the most used method due to its ease of use and versatility [47]. This method's efficiency remains low compared to three-dimensional (3D) gait analysis [48]. Analyzing the literature from 1990 to 2019, close to 30 research papers reference the linked studies. These detailed the comprehensive requirements for performing 2D video gait analysis in a clinical or research setting. Based on this evidence, we can conclude that 2D gait analysis has a promising future in this area. Recommendations are provided for dataset size, specific age group, adopted gait characteristics, agility activities, and data collection methodologies. After decades of development, detailed gait analysis measurement methods have been developed as an efficient tool for detecting specific gait problems. The high cost of the procedure, combined with the need for professional labor, limits the usage of this method to industrialized countries and economically capable patients. As a result, observation-based research remains the recommended method. Recent advances in low-cost wearable sensors and related technologies, particularly inertial body sensors, have paved the way for a superior alternative to observation-based methods. These sensors have enabled seamless mobility, the flexibility of usage, convenience of access, and accuracy in gait analysis which further benefits both the patient and the doctor by assisting data collection and requiring minor observation. Human gait analysis is a valuable tool for early and accurate disease detection and is potent for post-operative treatment and follow-up services. Another helpful way is to capture biomechanical characteristics and related metrics in clinical, sport, and exploration settings. Depending on the source of the problem, these factors are further classified as musculoskeletal, neurological, and circulatory. Different statistical/mathematical methods are used to evaluate and explain these parameters [53]. These studies support and strengthen the efficacy of gait analysis. In particular, assessing parameter values in fig. 1 such as an individual's step length, step width, stride length is critical in conducting a thorough gait analysis [54].

RESULTS

The systematic search yielded 272 hits, 11 of which were added retroactively by reference filtering of the included papers. Fifty-three articles were retained for full-text screening following title and abstract screening, with 20 eventually meeting the intended eligibility requirements. Fig. 2 depicts the entire flow diagram of the screening procedure. Many investigations have developed new sensor-based technology software to track gait phases in clinical settings and at home among patients with mobility impairments for tailored training, as well as a pilot study with healthy people. All included articles are complemented with a table that provides a list of all outcome measures and how they were investigated in terms of study participants (Table-1).

DISCUSSION

This review article aimed to look at the issues that come with knee osteoarthritis and knee arthroplasty and how they can be managed in the healthcare system using Telerehabilitation. Much research has been conducted and published on the effect of Telerehabilitation in managing the challenges that the public has with pre- and post-knee rehabilitation in knee osteoarthritis [81]. Following a review of the various available literature from 2010 to 2021, it is suggested that there is a need for early investigation and examination to rule out the severity and actual status of the joint problem in terms of mobility, articular and non-articular changes, and muscle strength status in patients with pre- and post-rehabilitation in the case of knee osteoarthritis [82]. Previous studies and literature emphasize the need for early evaluation and examination of the knee joint to confirm the correct diagnosis as soon as possible to fix the problem's actual status without delay [83]. Bioengineering has demonstrated the best results in technology-

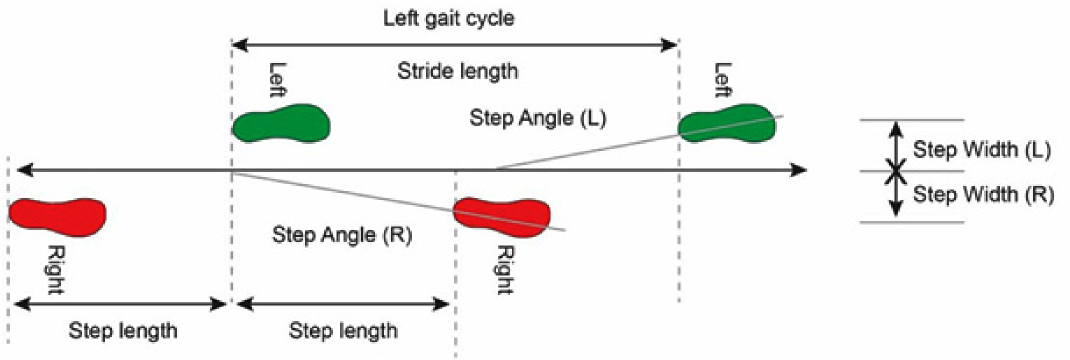

Fig. 1. Spatial parameters of gait cycle

based rehabilitation and evaluation modules for examining and treating patients through pre and post-knee rehabilitation [84]. The walking issues of people with knee osteoarthritis can be assessed and managed by several methods [85]. Gait analysis is important in examining human locomotion and quantitative documentation to acquire real-time data. However, gait labs require a vast area and expensive equipment to set up. As a result, a significant financial investment is required to build and launch a gait lab [86]. To alleviate the financial burden, wearable devices and sensor-

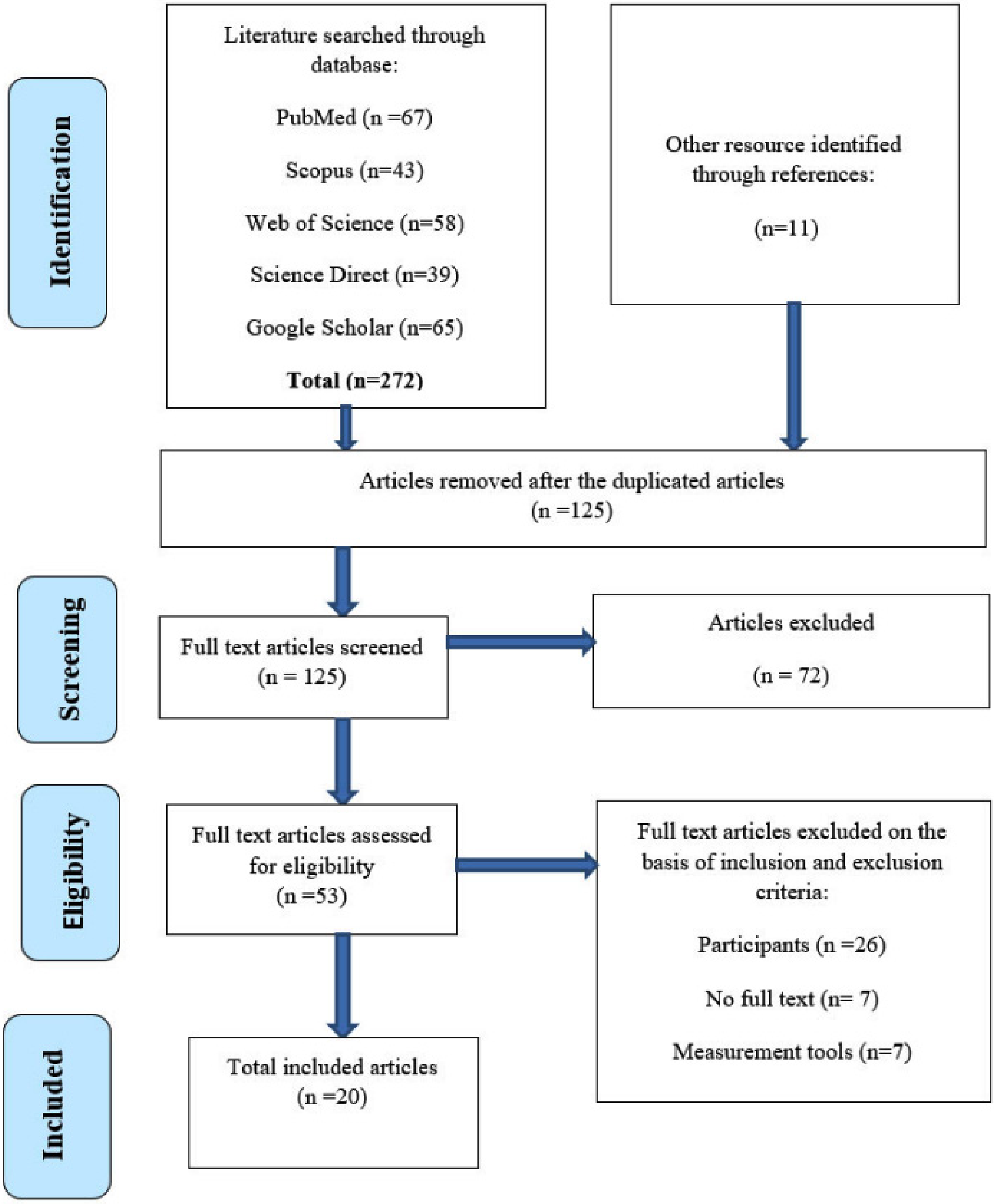

Fig. 2. Flow diagram of process adopted for screening the articles

Table 1. Studies included in the review

S. No.	Title	Parameters	Comments
1.	Biofeedback versus Physiotherapy in patients with partial weight bearing[55]	1. Smart step used for feedback[56] 2. TUGT[57] used for performance 3. VAS[58] used for pain	This study concludes that biofeedback is necessary for monitoring walking, performance, and limb loading.
2.	New approach for the rehabilitation of patients following total knee arthroplasty[59]	Gait variables; step length, stride length, single limb support, walking speed	Implementation of a new rehabilitation strategy (calibrated shoes) demonstrate the significant result in terms of improvement in gait variables
3.	Instrumented wireless smart insole for mobile gait analysis: A validation pilot study with Tekscan strideway[60]	Gait's spatiotemporal variable of Gait; step length, stride length, double limb support, and single-limb support. Cadence and walking speed	This multisensory system based technology demonstrate the beneficial result in monitoring and analyzing the gait parameters
4.	Design of a smart insole for ambulatory gat analysis[61]	Gait variables, plantar foot pressure	Multiple sensors integrated tool demonstrates a vital role to detect the plantar pressure and phases of Gait
5.	Gait analysis using a shoe-integrated wireless sensor system[62]	Gait cycle and phases, the orientation of the foot	The gait shoe proves remarkable to detect and analyze the different phases of the gait cycle and orientation of the foot
6.	Gait analysis using wearable sensors[63]	Gait parameters, kinematics, the kinetics of lower limb	With the development of wearable sensor-based technology and analyzing methods, it is extended to play an essential role in clinical application
7.	In-sole shoe foot pressure monitoring for gait analysis[64]	Gait parameters, plantar pressure	Force-sensitive resistor (FSR)[65] based insole detect the plantar pressure and movement on a real-time basis. It may be helpful in clinical gait analysis.
8.	Validation and reliability testing of a new, fully integrated gait analysis insole[66]	Kinetics, spatiotemporal parameters of Gait	A new tool (OpenGo, Moticon GmbH)[66] was introduced to detect the data of Gait's kinetics and spatiotemporal parameters continuously. It can be utilized in clinical long period.
9.	Position controlled Knee Rehabilitation Orthotic Device for Patients after Total Knee Replacement Arthroplasty[67]	Range of motion (ROM) of knee joint	Torque feedback-controlled device demonstrates a significant improvement in improving knee and walking speed ROM in patients after knee arthroplasty.
10.	Design and accuracy of an instrumented insole using pressure sensors for step count	Cadence, plantar pressure	FSR integrate insole was developed and used to detect the step count on a real-time basis. It shows highly accurate on cumulative sum-based method.
11.	Design of low cost smart insole for real time measurement of plantar pressure[68]	Plantar pressure	This novel insole provides the accurate time visualization of pressure mapping of the foot sole, and it can be used in rehabilitation and sports performance analysis.
12.	Smart Insole: A wearable system for gait analysis[69]	Gait parameters; step length, stride length, cadence, single support, double limb support, walking speed, foot orientation	This system was developed and utilized to detect the data of Gait of the patients and can transmit to Telehealth architecture to supervise the patients accordingly.
13.	Synchronized Sensor Insoles for Clinical Gait Analysis in Home-Monitoring Applications[70]	Gait parameters and plantar pressure	A new fully integrated low power sensor insole was utilized to detect the gait parameters and plantar pressure against the GAITRite[70] system as reference. It proved its ability to obtain synchronized data of Gait and address the requirement for home-monitoring stings over the clinical gait analysis.
14.	Effects of Wearable Sensor-Based Balance and Gait Training on Balance, Gait, and Functional Performance in Healthy and Patient Populations[71]	Gait parameters, balance measures	Specific gait parameters and balance measures may also improve through wearable sensors training, yet limited evidence is available.
15.	Validity of Instrumented Insoles for Step Counting, Posture and Activity Recognition[72]	Gait parameters, posture measure and body position measure; sitting standing, etc.	Instrumented insole appeared remarkably steady for step counting but variable in posture and body position due to heterogeneity.
16.	Wearable Sensor-Based Real-Time Gait Detection[73]	Gait phases; heel strike, foot flat, heel off, toe-off, etc.	This study recommends that the combination method, i.e., Inertial Measurement Unit (IMU)[74] and rule-based methods, is optimal for analyzing the gait phases on real-time data.
17.	Gait analysis of walking before and after medial opening wedge high tibial osteotomy[75]	Kinetics of knee joint	Vicon MX3 motion analysis system[76], two force plates adjunct with 10-meter walkway[77] were used to detect the knee joint's kinetic, resulting in the normalization of gait parameters like walking speed.
18.	IMU-based Gait Analysis for Rehabilitation Assessment of Patients with Gait Disorders[78]	Gait parameters; step length, stride length, cadence, single limb support, double limb support, etc.	A dual foot-mounted inertial measurement unit (IMUs) was developed to detect the gait variables during the examination of patients with gait disorders. It may also be helpful for healthcare professionals during their clinical practice.

19.	Technology-assisted rehabilitation following total knee or hip replacement for people with osteoarthritis[79]	Pain measures; VAS, gait parameters, and quality of life measure	This study shows that technology-assisted rehabilitation resulted in remarkable improvement in pain but less evident in function
20.	Gait assessment as a functional outcome measure in total knee arthroplasty: a cross-sectional study[80]	Temporal parameters of Gait, limb segment angles, knee angles	This study used inertial measurement units (IMUs) to detect the gait parameters, limb segment angle, and knee angle. There is less evidence in improving gait variable follow-up of 12 months after knee replacement.

TUGT= Timed Up Go Test, VAS= Visual Analog Scale, FSR= Force Sensitive Resister, IMU= Inertial Measurement Unit

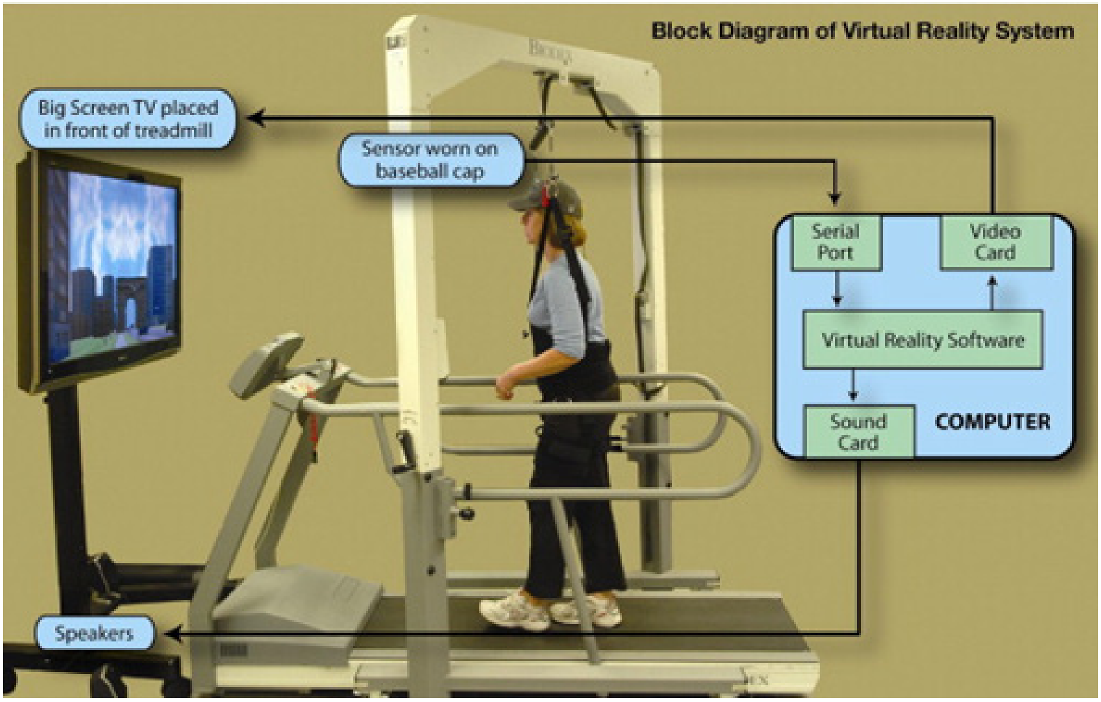

Fig. 3. Proposed rehabilitation model for early mobility for patients with walking difficulty[107]

based technologies are currently being used in gait labs to analyze and support patients with walking impairments before and after knee rehabilitation [87]. However, two measurement tools that have the potential to detect gait parameters, plantar pressure, and foot orientation without combining with other technologies with inertial sensors, namely insole and force-sensitive resistor and camera-based gait lab, were among the most included articles in this review [88]. Even though instrumented gait labs are more reliable for monitoring gait phases and their applicability is consistent over long periods until the user changes their footwear during gait study [89], camera-based gait labs may be preferable to sensor-based devices since they can provide information on the user's surroundings and social interactions [90]. However, camera-based instrumented labs are costly and not accessible to everyone, and they are difficult to use [91]. Other technologies, such as pressure sensor mats or pathways, sensor integrated shoes, and sensor integrated shoes, could be used to quantify gait characteristics and plantar pressure mapping [92]. However, these technologies are limited to a specific area, and every patient can't monitor their motor activity and related data in everyday life [93]. As a result, we are convinced that wearable sensor-based technology is the preferred measuring tool over instrumented gait labs for detecting and analyzing gait parameters in patients with aberrant gait parameters following knee surgery [94]. Meeting the basic needs of such technology-assisted rehabilitation is a serious concern in everyday life [95]. When it comes to rehabilitation and the use of technology-assisted devices in the dynamic condition of the lower limb, individuals with mobility limitations face several challenges [96]. Some clinical criteria for evaluating the functional status, such as the 10-meter walking test (10MWT), the 6-meter walking test (6MWT), and variability in Gait spatiotemporal parameters and ambulation during and after rehabilitation in various pathologies, have been supported [97] Traditionally, gait parameters and other data related to lower limb dynamics such as kinetics and kinematics were monitored using a gait analysis method. This method comprises instrumented motion analysis such as cameras, markers on different limb parts, various mathematical algorithms, and molded electro-goniometers [98]. Considering recent advances, sensor-based technology-assisted wearable and non-wearable tools or devices such as smart insoles, shoes, and smart watches are widely used. These tools provide satisfactory and potential output in terms of the reliability and validity of data collected and monitored during examination and evaluation in the entire process of rehabilitation with various ailments [99]. However, all such wearable and non-wearable technology-assisted devices have limitations in monitoring all parameters to their full potential [100]. This technology-assisted rehabilitation is only offered in a few clinical settings or hospitals. It is not cheap for all patients experiencing difficulties with mobility, functional status, and ambulation following lower limb surgery [101]. Technology-assisted rehabilitation is particularly crucial for patients who live in rural or remote areas because they face numerous problems, such as not being able to finance it and failing to come and report to the hospital regularly to evaluate their health status [102]. As a result, there is a need to create and implement Telerehabilitation services that include technology-assisted rehabilitation, which can help patients empower themselves for self-decision making and health status maintenance, resulting in an improvement in overall wellbeing [103]. In the current scenario, there is a need for sensor-based technology that is more reliable and valid than typical systems such as instrumented gait labs, which may assist doctors and patients and play an essential role in the health care system [104]. In the future, these technology-based interventional approaches may be a viable alternative to current methods for practitioners and patients, both in the clinical context and at home [105]. However, it is critical to focus on the budget and viability of this technology-based rehabilitation because it is still expensive and difficult for everyone to use and operate [106]. If this technology is built on a modest budget and with simple handling abilities, many people will profit from it, setting a standard in the healthcare system. IMUs were the most popular technology among wearable sensors in the articles included in this review. We believe that the utility of wearable sensor-based technologies is determined by several factors, including the number of sensors, positioning of sensors, and location of sensors that can be used to monitor and gather data on various aspects of everyday life.

CONCLUSION

This review concludes that there is a need for early rehabilitation after TKA to obtain potential benefits in terms of muscle strength, mobility, walking pattern, and quality of life. Various wearable and sensor-based technologies are available in the health care system for optimal mobility and mode of ambulation of the patients. In the future, we will develop a rehabilitation model for patients who require early rehabilitation after lower limb surgery. Early rehabilitation will require establishing a setup embedded with a monitored treadmill as a walking platform and adjunct with pressure and motion sensors mat with automated and manual operational skills.

Cameras will be located at the front and back of the user to monitor the postural status. A monitor will show the status of gait parameters, foot orientation, limb loading, and speed variability. We anticipate that this rehabilitation paradigm will be an effective method for achieving early mobility for individuals with mobility limitations due to various pathologies. It can aid in the resolution of postoperative issues involving functional status, mobility, and ambulation. Early rehabilitation and sensor-based technologies can be used to obtain better results and outcomes and accelerate the recovery rate. This review attempted to showcase these established technologies to carve out a better technological intervention to treat the same with the assistance of sensor-based monitoring to minimize overall costs and boost the effect of administered physiotherapy.

Conflict of Interest

The authors have no conflicts of interest to declare.

Research involving human participants and/or animals

Not applicable

Informed consent

Not applicable.

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Ethical Statement

An ethical statement is not applicable because this study is based exclusively on published literatures.

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