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Analysis on Manifestations of Bilateral Leg Differences and the Application Value of Gait Analysis for Injured Populations

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ABSTRACT

Unilateral lower limb injury is one of the most common musculoskeletal conditions encountered in orthopedic rehabilitation. In clinical practice, both healthcare providers and patients often hold a fixed understanding of recovery: it is commonly assumed that once structural healing of the injured bone and soft tissues is complete and symptoms such as swelling and pain have fully resolved, lower limb motor function will return to normal. However, long-term clinical follow-up and case tracking reveal significant limitations in this assumption. Even after anatomical structures at the injury site have healed completely, many patients still exhibit noticeable deficits in bilateral coordination and load distribution, failing to meet physiological standards observed in healthy individuals. These subtle, hidden functional asymmetries gradually alter gait patterns during daily activities, eventually leading to compensatory gait patterns that are difficult to correct independently. Prolonged maintenance of abnormal walking patterns continuously causes friction and wear on joint cartilage and surrounding soft tissues, significantly increasing the risk of degenerative joint changes and recurrent injuries. Currently used clinical methods-such as imaging studies and manual physical examinations-can only assess the structural healing status of limbs directly but struggle to detect subtle, concealed dynamic functional impairments. Based on frontline rehabilitation experience and fundamental principles of biomechanics, this article systematically analyzes the common bilateral functional differences in patients with unilateral lower limb injuries from three core dimensions: gait rhythm, lower limb loading characteristics, and muscle synergies, exploring the practical value of gait analysis technology throughout the entire rehabilitation process. Follow-up data from numerous clinical cases indicate that the body's natural tissue repair mechanisms can achieve structural healing but cannot fully restore functional deficits caused by injury. Imbalanced bilateral loading and reduced precision in muscular control represent the most central and widespread functional impairments among these patients. Gait analysis technology enables precise quantification of subtle functional differences between limbs, minimizing subjective assessment errors, thereby supporting personalized rehabilitation interventions and targeted correction of abnormal gait patterns. It also effectively prevents secondary injuries, making it an essential, highly practical, and accurate diagnostic tool in modern, precision-based rehabilitation care.

KEYWORDS

Lower limb injury; Leg function differences; Gait analysis; Biomechanics; Rehabilitation assessment.

1. INTRODUCTION

Various injuries of the lower limb bones, joints and soft tissues are very common in orthopedic outpatient clinics and sports medicine specialist clinics. Most of the injury cases admitted to the clinic are concentrated on unilateral lower limb involvement, while bilateral lower limb injuries occurring simultaneously are extremely rare. This is also the main cause for the limitation of walking function and the decline of overall movement ability in the general population, fitness enthusiasts and professional sports people. Most people have a relatively shallow understanding of walking exercises,

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merely defining them as simple repetitive limb movements, while ignoring the complex mechanical transmission laws and multi-tissue collaborative operation mechanisms during walking. The stable and standard walking posture of the human body cannot be achieved without the precise coordination and dynamic balance of the lower limb muscle groups, weight-bearing joints and the trunk. Once a unilateral lower limb suffers from acute trauma or long-term chronic strain, the long-term stable mechanical balance system maintained by the body will be completely disrupted. Even minor conditions such as slight meniscus wear and mild ligament strain will still leave subtle walking abnormalities that are difficult to be identified by the naked eye in the limb interior, and these hidden problems will continuously interfere with the overall rehabilitation prognosis of the patient, making the functional recovery difficult to reach the ideal state [1].

At present, the rehabilitation efficacy assessment of patients with lower limb injuries in most domestic medical institutions mainly relies on the results of imaging examinations, manual physical examinations by medical staff, and the subjective feelings of the patients. This traditional assessment model is convenient to operate and applicable in a wide range of scenarios, meeting the basic diagnostic needs, but it has inherent shortcomings that cannot be avoided. The entire assessment system lacks unified and quantified determination standards, and the final results are highly dependent on the clinical working experience of medical staff, making subjective judgment deviations inevitable. Many subtle functional differences between the two legs and hidden abnormal forces on the limbs will be missed during physical examinations. The lack of assessment accuracy directly leads to the subsequent rehabilitation training often adopting standardized template schemes, which are difficult to fit the individualized functional defect characteristics of each patient. The rehabilitation progress and recovery effects of different patients vary, and the accuracy of efficacy assessment cannot be guaranteed, making it difficult to adapt to the development trend of modern rehabilitation medicine that pursues refined and personalized diagnosis and treatment [2].

In long-term clinical rehabilitation work, there is always a relatively common cognitive bias within the industry, with the treatment focus overly focusing on the healing and repair of tissue structures, but neglecting the reconstruction and recovery of the core movement functions of the limbs. Most clinical scenarios will take the normal imaging indicators and the absence of subjective pain or swelling symptoms as the core standards for rehabilitation conclusion. However, the accumulated clinical cases over the years have already proven that the anatomical healing of tissue structures and the complete recovery of limb movement functions are two independent rehabilitation dimensions. The healing of superficial and deep tissue wounds does not mean that the functions of lower limb movement, control and balance can be restored simultaneously. Hidden sequelae such as abnormal walking postures, uneven bilateral force distribution, and abnormal muscle force patterns will persist in the patient's body for a long time. These imperceptible functional problems are precisely the important causes of old injuries recurring and joints prematurely aging and deteriorating. The application of gait analysis technology effectively fills the technical shortcomings of the traditional rehabilitation diagnosis model [3]. This technology can rely on professional detection equipment to comprehensively collect multi-dimensional basic data such as walking postures, foot pressure distribution, and muscle activity signals of patients, converting previously vague and difficult-to-determine functional problems into intuitive, comparable and traceable quantitative indicators, completely getting rid of the subjective limitations of traditional empirical assessment.

Long-term follow-up data after various lower limb injuries further confirm the universality of hidden functional deficiencies. Patients who have undergone surgeries such as ligament reconstruction, meniscus repair, and Achilles tendon repair, after the complete disappearance of subjective pain, swelling and other discomfort symptoms, still have significantly lower stability of two-leg walking and efficiency of force transmission compared to healthy people. Gait asymmetry is the most representative long-term sequelae for patients with unilateral lower limb injury. The long-term and fixed abnormal gait pattern will form a vicious cycle, continuously degrading joint functions and weakening muscle strength. Based on extensive clinical observations, existing academic research

results, and first-line rehabilitation practical experience, this article systematically summarizes the functional differences between the two sides of the limbs in patients with unilateral lower limb injury, clarifies the application value of gait analysis techniques in the entire rehabilitation diagnosis and treatment process, and provides a reference for clinical refined rehabilitation intervention.

2. THE MAIN CHARACTERISTICS OF THE FUNCTIONAL DIFFERENCES BETWEEN THE TWO LEGS OF PATIENTS WITH LOWER LIMB INJURIES

The traditional clinical diagnosis approach mostly focuses on the obvious local symptoms caused by lower limb injuries, the most common of which are muscle strength reduction and limited joint range of motion. With the continuous popularization of biomechanical detection technology and the continuous accumulation of clinical case data, clinical research has found that the impact of unilateral lower limb injury is not limited to the injured area; it can also cause systemic adaptive changes in limb functions throughout the body. Trauma directly damages the normal anatomical structure of the lower limbs, interferes with the precise regulation of the central nervous system over the lower limb limbs, and completely reshapes the walking force pattern and muscle coordination operation habits formed by the human body at birth [4]. The injury sites, severity of injury, and rehabilitation intervention periods of different patients vary, and in addition to individual physical differences, the clinical manifestations of asymmetry in both legs also have obvious individual characteristics. Considering the common patterns of frequently admitted clinical cases, the functional differences of both limbs in patients with unilateral lower limb injury mainly concentrate in three core aspects: walking spatial parameters, joint load mechanics, and muscle coordination patterns.

2.1 The Asymmetrical Movement of the Legs During Walking Caused by Spatial Parameters

Step length, step frequency, complete walking cycle, duration of limb support, and duration of limb swing are the core fundamental indicators for clinical assessment of human walking stability and limb coordination. The gait parameters of both lower limbs in healthy individuals are always in a balanced and stable state, with smooth and relaxed walking postures, without abnormal manifestations such as limb dragging or body center of gravity deviation. After a unilateral lower limb suffers structural damage, the body will spontaneously activate protective compensation mechanisms, which is also the core trigger for the formation of pathological gait. To avoid pain stimulation during walking and to make up for the insufficient stability of the damaged joint, patients will autonomously adjust their body posture and limb force application methods, actively reducing the load on the affected lower limb, thereby maintaining basic walking balance [5].

This spontaneous protective walking posture of the body can ensure that patients can complete daily basic walking and alleviate short-term physical discomfort, but it completely disrupts the original force distribution and movement rhythm of the two legs. The compensatory gait formed in the early stage of injury has high plasticity and can be completely corrected through standardized rehabilitation intervention. If patients miss the early rehabilitation opportunity and do not receive systematic gait correction training, the abnormal gait formed in the short term will solidify within several months and evolve into a difficult-to-reverse pathological gait. Such stubborn functional abnormalities will significantly increase the difficulty of subsequent rehabilitation and correction, and hinder the recovery of all aspects of limb function. Different types of lower limb injuries trigger distinct abnormal gait patterns, and the clinical identification is relatively high. Meniscus injury is the most common disorder that disrupts the walking rhythm, and it accounts for a high proportion of clinical consultations. These patients generally have problems such as shortened gait on the affected side and limited movement of the hip and ankle joints. Based on the statistical data from clinical measurements, the duration of limb support on the affected side of patients with meniscus injury is 15% to 20%

longer than that on the healthy side, and the swing rate of the limbs is significantly reduced, with particularly prominent abnormal signs such as walking drag and center of gravity deviation [6].

Compared to meniscus injury, the abnormal gait caused by Achilles tendon injury is highly concealed and difficult to detect through routine visual observation or basic physical examination. In clinical conservative treatment, most patients with mild to moderate Achilles tendon injuries have good recovery results, and the overall walking frequency and walking cycle do not show significant abnormalities, only a slight reduction in the gait on the affected side. Although this seemingly minor parameter deviation can directly lead to poor coordination of the walking action and dynamic imbalance of the body, it poses a potential risk for long-term limb dysfunction. Combining long-term clinical follow-up, it is easy to find that most patients with Achilles tendon injury have poor rehabilitation outcomes in the later stage and the injury recurs and persists. The root cause lies in the early undetected and uncorrected hidden abnormal gait. The functional gap between the two limbs will continue to accumulate and expand over time, eventually forming permanent functional deficits that are difficult to repair [7].

2.2 The Mechanical Differences between Joint Movement and Leg Force Application

The joint movement angles, peak force on the sole of the foot, and the strength of the flexion and extension muscles of the joint can directly reflect the actual force state and movement efficiency of the lower limbs, and are important indicators for evaluating the quality of limb function. Abnormal external walking postures can be identified directly by the naked eye, but internal hidden problems such as uneven force distribution and mechanical imbalance in both lower limbs cannot be detected through routine physical examinations. Such easily overlooked functional abnormalities can gradually and imperceptibly damage the joint structure over a long period of time, causing significant negative impacts on the patient's long-term joint health and functional prognosis. It is worth noting that such biomechanical disorders cannot be repaired by healing the trauma and will continue to accumulate and worsen in the daily walking activities [8].

The anterior cruciate ligament of the knee joint is the core anatomical structure that maintains the dynamic stability of the knee joint and plays a crucial role in the normal force distribution and movement conduction of the lower limbs. After the ligament is injured or completely ruptured, the range of motion of the knee joint will be directly restricted, and the overall stability performance of the joint will significantly decline. During the critical stage of landing and buffering in walking, the affected side of the knee joint cannot complete the normal force-creating action or effectively buffer the impact force generated by the ground. To maintain body balance and complete the complete walking action, the human body will spontaneously transfer most of the body weight to the healthy side of the lower limb. Long-term clinical follow-up results have confirmed that the compensatory force distribution pattern formed after injury is persistent and irreversible. The healthy hip and knee joints will remain in an overloaded bearing state for a long time, eventually forming a fixed bilateral lower limb mechanical imbalance pattern [9].

Multiple long-term follow-up studies on patients after lower limb injury have verified this clinical rule. Young and middle-aged patients who underwent anterior cruciate ligament reconstruction surgery in the postoperative 2 to 7 years of daily walking and light exercise scenarios, the biomechanical parameters of both lower limbs could not always return to a symmetrical level. The energy reserve, force output, and stress conduction functions of the affected side of the lower limb would continuously decline, while the healthy side of the lower limb would long-term compensate for the bearing weight, and there would be problems such as local stress concentration and uneven overall force distribution. The biomechanical imbalance, abnormal gait, and joint degeneration would form a closed vicious cycle. Abnormal limb force distribution would continuously wear down the joint cartilage, aggravating the structural damage of the joint, and the joint damage would further

exacerbate the gait deviation, which is also the core reason why most patients still develop knee degenerative lesions even after their clinical symptoms have completely subsided.

2.3 The Differences in the Way Legs are Used and Coordinated During Muscle Activation

Disorder in the force distribution of lower limb joints is the most obvious and easily identifiable clinical sign of unilateral lower limb injury. When the sequence of muscle activation is disordered and the coordination of bilateral muscle groups is disrupted, it represents a deep and hidden functional deficiency that is easily overlooked during clinical screening. Whether it is a sudden acute trauma or a long-term chronic strain, it will completely change the original muscle force mechanism and multi-muscle group coordination logic of the lower limbs. The injury will directly interfere with the initiation timing, contraction intensity and single-shot work efficiency of the muscles, completely destroying the inherent linkage regulation pattern of the limb. Some patients' muscle strength test indicators can return to the normal reference range, but the deep neural and muscle control ability and bilateral limb coordination regulation function have already suffered irreversible damage, unable to meet the limb regulation requirements for daily activities and sports [10].

Unilateral lower limb injury will cause the overall muscle group function of the affected side to decline. Clinically, it mainly manifests as delayed muscle activation, insufficient peak muscle strength, and a significant reduction in muscle work efficiency during walking. To compensate for the functional defect of the affected limb and maintain the dual balance of the body in static and dynamic states, the muscle groups on the healthy side will remain in a high-intensity compensatory contraction state for a long time. This abnormal force-ful mode completely breaks the standardized muscle group coordinated movement pattern of healthy people, directly causing walking force disorder, insufficient limb support stability, and body posture imbalance, and ultimately leading to a significant decline in the patient's walking quality and overall movement ability.

The application of surface electromyography technology can accurately capture these subtle muscle functional abnormalities, providing objective and quantitative data support for clinical assessment. From the clinical measurement results, during the walking process of patients after anterior cruciate ligament surgery, the thigh muscle groups on the affected side cannot effectively complete core actions such as stress buffering and joint stabilization, and can only rely on the overcompensation of the ankle muscle groups to maintain body balance. Long-term overloading operation will lead to the continuous stiffness of the lateral and posterior thigh muscle groups on the healthy side, easily triggering secondary soft tissue lesions such as chronic strain [11]. Current academic research speculates that the compensatory mode of lower limb muscle disorder has gender heterogeneity, and in clinical practice, subtle differences in the distribution of compensatory muscle groups between male and female patients can also be observed, but this conclusion still needs to be further supported by large-sample controlled studies. For patients with meniscus injury, the decline in thigh muscle force efficiency and insufficient limb support stability are core functional problems, and the severity of bilateral gait asymmetry will gradually increase as the rehabilitation cycle progresses.

3. THE PRACTICAL APPLICATION VALUE OF GAIT ANALYSIS TECHNOLOGY FOR PATIENTS WITH INJURIES

By combining the functional differences of the two limbs in patients with unilateral lower limb injury, it is easy to see that the traditional clinical assessment model has inherent technical shortcomings and is no longer able to meet the modern rehabilitation medicine's requirements for refined and individualized diagnosis and treatment. Gait analysis technology, with its core advantages of precise quantification, dynamic monitoring, and traceable data, comprehensively covers the entire cycle of diagnosis and treatment for lower limb injury rehabilitation. In key aspects such as disease screening

and diagnosis, customizing rehabilitation plans, objectively evaluating treatment efficacy, and preventing long-term risks, it has clinical application value that cannot be replaced by traditional physical examinations or imaging tests [12].

3.1 Accurately Quantify the Condition and Make up for the Shortcomings of Traditional Examinations

The core problem of the traditional clinical assessment system lies in the disconnection between static structural examination and dynamic functional assessment, resulting in large areas of diagnostic blind spots. Imaging examinations can clearly present the postoperative healing morphology of bones, ligaments, and menisci, and accurately determine the repair status of tissue structures. However, they can only reflect the anatomical healing effect of the limb in a static state and cannot capture the dynamic stress changes during the patient's walking process, nor can they quantify the subtle functional differences between the two sides of the limb. Manual physical examination is entirely based on the clinical experience of medical staff and lacks unified and standardized quantitative assessment criteria. Subjective errors cannot be avoided, and many subtle and concealed functional deficiencies will be missed in routine examinations [13].

Gait analysis technology fundamentally breaks through the technical bottlenecks of traditional assessment. This technology integrates multi-dimensional detection methods such as dynamic image acquisition, foot pressure monitoring, and electromyography detection, and can fully collect the dynamic parameters of the patient's entire walking process. Medical staff can rely on the system's detection data to accurately determine the severity of limb asymmetry, clearly distinguish primary structural abnormalities from secondary compensatory functional abnormalities, and precisely locate the rehabilitation targets that require key intervention. In clinical diagnosis and treatment, it is often found that some patients have a good subjective sensation, and routine imaging and physical examinations indicate that the anatomical healing meets the standards. However, the refined gait detection data still show significant functional deficiencies. These undetectable hidden problems are the core causes of the overall poor rehabilitation efficacy of most patients.

In routine clinical diagnosis and treatment, most patients with unilateral lower limb injuries will have their pain and swelling completely relieved after 1 to 3 months of basic treatment. Clinically, this is usually judged as the initial rehabilitation. However, long-term follow-up data repeatedly confirm that hidden functional abnormalities such as gait asymmetry, limb biomechanical imbalance, and muscle group coordination disorder cannot be repaired by the body's self-healing mechanism and will persist throughout the rehabilitation period, continuously affecting the recovery of limb function. The limitations of traditional examination methods cause a large number of patients to miss the rehabilitation golden window period of 3 to 6 months after surgery. Comparative results of multiple clinical data sets fully prove that the assessment accuracy of gait analysis is far superior to that of traditional manual examination and can provide scientific and reliable data support for disease classification and comprehensive assessment of limb function.

3.2 Assist in Formulating and Optimizing Personalized Rehabilitation Plans

The ultimate efficacy of rehabilitation intervention mainly depends on the degree of matching between the rehabilitation plan and the individualized functional deficits of the patients. Traditional homogeneous rehabilitation training has a wide application range and can meet basic rehabilitation needs, but it lacks sufficient targeting and specificity. The uniform and standardized training content cannot adapt to the specific gait abnormalities and functional deficiencies of different patients, which is also the key reason why many patients do not achieve thorough rehabilitation and have poor functional recovery results in clinical practice. The indiscriminate homogeneous intervention mode not only cannot effectively correct compensatory abnormal gait but also continuously aggravates the

functional imbalance of both limbs, which has a negative impact on the long-term limb function reconstruction [14].

The quantitative parameters provided by gait analysis offer precise basis for the formulation of personalized rehabilitation plans. Medical staff can rely on precise detection data to identify the core causes of patients' gait abnormalities, clearly distinguish different types of functional lesions such as rhythm disorders, mechanical imbalance, and muscle group coordination disorders, and clearly define the core focus of rehabilitation training. Based on these objective data, traditional single template training can be optimized into targeted and precise individualized rehabilitation intervention plans. Clinically, layered training can be carried out based on the patient's differentiated gait parameters, significantly improving the accuracy and effectiveness of rehabilitation intervention. For patients with uneven step length and disordered walking rhythm, gait correction and balance training can be focused on, standardizing and standardizing the walking posture, and improving the overall coordination ability of the limbs; for patients with weakened muscle strength on the affected side and mechanical imbalance of both limbs, the focus of rehabilitation can be on strengthening the core muscle strength on the affected side, restoring the joint load-bearing and stress transmission function, and gradually achieving mechanical balance of both lower limbs; for patients with abnormal muscle activation sequence, muscle electrical feedback training can be used to correct abnormal force application patterns, and restore the normal neural-muscular regulatory function of the body [15].

Different from the traditional static rehabilitation assessment mode, gait analysis can realize dynamic monitoring throughout the rehabilitation cycle, and track the progress and trend of patients' functional recovery in real time. Medical staff can adjust the training intensity and optimize the training content flexibly based on the dynamically updated quantitative data, effectively avoiding common problems such as excessive training, insufficient training, and deviation in intervention direction, and continuously optimizing the rehabilitation prognosis of patients. This dynamic and precise intervention mode is a core advantage that traditional empirical rehabilitation training does not have, and can best meet the individualized rehabilitation needs of each patient, significantly improving rehabilitation efficiency and recovery quality.

3.3 Objective Assessment of Rehabilitation Outcomes and Prediction of Subsequent Recovery Scenarios

With the continuous iteration and update of modern rehabilitation medical diagnosis and treatment concepts, the traditional single and one-sided efficacy evaluation system has been improved, and the industry has completely changed the outdated standards that only relied on structural healing and symptom disappearance to determine the rehabilitation effect. In the current refined rehabilitation diagnosis and treatment, the symmetry of bilateral lower limb gait and the stability of limb mechanical balance have become the core quantitative indicators for evaluating rehabilitation quality and predicting the long-term motor function level of patients.

There are a large number of typical cases in clinical diagnosis and treatment, which can fully demonstrate the importance of functional assessment. Some patients have completely repaired their anatomical structures and completely eliminated clinical discomfort symptoms, and according to traditional assessment standards, they have reached the rehabilitation standard. However, there are still significant deficiencies in deep walking function and movement control function. Such patients cannot participate in various sports activities normally, and they are accompanied by signs such as walking weakness and abnormal posture for a long time. Their motor ability cannot always recover to the healthy baseline. Anatomical structure repair and limb function reconstruction are two independent core dimensions in the rehabilitation process. A high-quality rehabilitation outcome requires simultaneously meeting four core conditions: complete anatomical structure, standard gait pattern, balanced mechanical load, and stable limb function. By comparing the longitudinal gait parameters of patients before surgery, during the rehabilitation mid-stage, and during the follow-up

period, it is possible to objectively quantify the rehabilitation efficacy, avoid the one-sidedness of subjective evaluation, and make the rehabilitation assessment work more scientific and accurate [16].

The quantitative parameters of gait in patients' early postoperative period have extremely high prognostic assessment and reference value. The knee joint flexion and extension symmetry, load balance index, and foot pressure symmetry coefficient from 3 to 5 months after surgery can directly reflect the patient's long-term limb function recovery level. If patients cannot effectively improve core problems such as mechanical imbalance and muscle group coordination disorder during the rehabilitation mid-stage, the risk of injury recurrence and secondary knee osteoarthritis will significantly increase. Based on dynamic gait data, early precise intervention can be carried out to promptly correct the already solid compensatory gait, weaken the continuous damage of abnormal mechanical patterns to the joints, and effectively optimize the patient's medium and long-term rehabilitation prognosis, and minimize the probability of long-term complications.

3.4 Prevent Secondary Injuries and Reduce the Risk of Rehabilitation

The secondary injuries caused by residual abnormal gait are a hidden risk that is easily overlooked in clinical rehabilitation, and they are also an important factor affecting the long-term rehabilitation quality of patients. Most patients have general cognitive biases regarding rehabilitation, simply equating wound healing and symptom disappearance with complete recovery, while ignoring the chronic cumulative damage caused by the long-term compensatory gait. Short-term minor functional deficits will continuously accumulate and worsen in daily activities, gradually progressing to stubborn pathological changes, inducing permanent damage to joints and muscle groups, and continuously reducing the patient's motor ability and quality of life [17].

From the summary of clinical cases, the secondary injuries after lower limb injury can be divided into two categories: new injuries on the healthy side and permanent functional deficits on the affected side. The healthy side limb continuously bears excessive load and abnormal stress, which will continuously present problems such as joint mechanical disorders and local stress concentration, gradually inducing new diseases such as joint cartilage wear and chronic muscle group fatigue. If the compensatory gait of the affected side limb is not promptly and properly corrected, it will permanently solidify into an abnormal movement posture, completely disrupting the physiological movement trajectory of the lower limbs, and ultimately causing irreversible damage to walking and movement functions [18].

Gait analysis technology can achieve early screening of hidden mechanical imbalance problems, accurately identify the risk sources of secondary injuries, and provide a clear direction for clinical intervention. Combined with targeted gait correction and muscle strength balance training, it can effectively balance the force state of both limbs, blocking the occurrence and progression of secondary injuries from the root. The results of multiple clinical controlled studies have confirmed that individualized rehabilitation plans based on gait quantitative data have stable and reliable intervention effects. This precise intervention model can balance the muscle strength of both lower limb groups, optimize the biomechanical transmission pathway of the lower limbs, and significantly reduce the risk of long-term secondary movement injuries [19]. Compared with the traditional homogeneous rehabilitation model, precise gait intervention can completely correct the patient's long-term formed incorrect movement habits, help them rebuild the physiological standard gait, and facilitate their smooth return to daily life, sports, and social work, with extremely high clinical promotion and application value.

4. CONCLUSION

Based on the existing academic research results and years of clinical rehabilitation experience, it can be determined that the core functional abnormalities in patients with unilateral lower limb injury mainly manifest as three types: abnormal walking rhythm, joint mechanical imbalance, and abnormal

muscle group coordination patterns. These specific bilateral limb functional differences cannot be eliminated spontaneously with the healing of the anatomical structure and will persist in the patient's body for a long time. They are also the core risk factors for the persistence of pathological gait, poor rehabilitation efficacy, and high incidence of long-term joint damage in clinical patients. The traditional imaging examination combined with manual physical examination assessment model has significant shortcomings such as large subjective bias, insufficient accuracy, and high rate of missed diagnosis. It has become unable to meet the clinical needs of current refined rehabilitation treatment.

The core clinical application value of gait analysis technology lies in its ability to accurately capture and quantify various subtle and hidden limb functional impairments, effectively compensating for the inherent shortcomings of the traditional assessment system. This technology covers the entire rehabilitation treatment process of injury screening, plan customization, efficacy determination, and prognosis assessment, providing solid theoretical and practical support for precise rehabilitation of lower limb injuries. This study has certain objective limitations. The research content mainly relies on literature review and clinical experience summary, without conducting independent-designed controlled clinical trials and lacking original clinical data as support. At the same time, the study did not conduct refined stratified analysis based on patient age, injury severity, and rehabilitation cycle, and cannot yet define the quantitative critical indicators for the impact of abnormal gait on long-term rehabilitation prognosis.

Future related research can expand the clinical sample size, add healthy control groups, and refine case stratification, etc., to systematically summarize the recovery patterns of limb functions in different populations and further improve the standardized system of individualized rehabilitation intervention. Clinical rehabilitation treatment work needs to completely abandon the traditional diagnostic thinking of "emphasizing structure, neglecting function", and regularly integrate gait analysis technology into the entire rehabilitation assessment process. Medical staff can use precise quantitative parameters to carry out targeted corrective training, optimize the overall biomechanical state of the lower limbs, reduce the risk of long-term complications, and help patients achieve comprehensive and high-quality reconstruction of lower limb motor functions.

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