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Review on the Clinical Application of Gait Analysis

Abstract Gait analysis is a method of studying walking rules. It is an important part of functional evaluation of low extremity. This article reviewed two kinds of gait analysis methods and their advantages and disadvantages. Their advance and application in our country would be included..

Keywords: Gait; Gait analysis; Rehabilitation evaluation; Review;

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Introduction

Walk dysfunction is one of the factors that affects patient capacity of the daily independent living and needs to be restored urgently. With the increased incidence of cerebrovascular disease, accidents and injuries year on year, there will be a large number of patients with lower limb dysfunction need for rehabilitation now and in the future.

Before and after treatment in the rehabilitation, it needs an objective, scientific assessment of the state of the lower limb function to understand the function of lower limbs and the effect of the rehabilitation therapy. Gait analysis (GA) is the study of walk way to check on foot, lower limb function, and is an important part of assessment. By means of biomechanics and kinematics, it can not only reveal abnormal gait and key factors to guide the rehabilitation assessment and treatment, but also help the clinical diagnosis, assessment of efficacy and mechanism research [1]. The purpose of gait analysis is to identify the mechanisms and causes of abnormal gait, to access to quantitative gait data, to select the optimal treatment strategies and to evaluate rehabilitation treatment [2].

1. Gait analysis

1.1. Qualitative analysis

The physician observe patients visually in the joints, muscles, pelvic movement and posture coordination in three directions from the front, the rear and the side during walk [3]. Visual method is simple and suitable for all levels of medical institutions, and is a systematic functional assessment of gait before the necessary evaluation. But this method is not quantitative but often a strong subjective, and because of the complexity of the human gait, diversity, and different therapists that there is a big limitation of its clinical application.

1.2. Quantitative analysis

It is a quantitative inspection and analysis method for visual description of limb movements during walking, and provides an effective way for clinical assessment of lower extremity functional status.

1.2.1. Kinematic Analysis

Get hip, knee, ankle and pelvic movement angles by pasting reflective signs at the surface of joints with 4-6 cameras getting trajectories of walking landmarks. Use the internal axis and Euler rotation angles to describe the three-dimensional motion of the joints during walking [4].

Kinematic parameters include: pelvic tilt and rotation angle; hip flexion, abduction and adduction angle; knee flexion and abduction angle; ankle dorsiflexion and toe flexion angle; and toe range of motion. They have been used to describe and compare the types of pathological gait [5]. However, this method is complex and time-consuming and difficult in clinical use that they have been more chosen by scientific researchers [2].

1.2.2. Kinetics analysis

It includes the pressure analysis and load analysis during the movement. Two force plates have been used to measure the plantar pressure distribution and the ground reaction force in the support phase of walking, including the vertical stress, the horizontal and lateral shear and the plantar force area. In addition, there is a specially equipped inner sensor in the shoe which can measure the plantar pressure on different parts of [2]. But this method cannot obtain the walking space variables.

1.2.3. Temporal-spatial analysis

Walking time - space variables can be obtained through the footprint method that the sole of the foot coated with ink should walk through the pedestrian access (typically 4-6m) covered with white paper [6] or with pulverized lime [7]. Times have been recorded by the stopwatch. Walking variables of step length, stride length and step width can be obtained from footprints. Although the footprint method is simple and quantitative, it is lack of accuracy and cumbersome for the testing process that it is difficult to be accepted in clinical practice. Now the electronic walk pad inserted with baroreceptor can record the real-time walking variables. It can measure time - space variables such as the single foot / feet support time, swing time and pace, etc. [8] in addition to the above. By comparing with gait analyzing results of the normal or the pre-treatment, it can access the type of pathological gait and treatment effects for further clinic treatment. This method can collect real-time walk parameters, and is objective, quantitative and accurate that it can be used as simple and sensitive indicators of clinical application.

1.2.4. Dynamic electromyography (EMG)

It is an effective method to detect muscle activity during walking. It can analyze and record the time and intensity of the muscle activity. The superficial muscle should use the surface electrodes while the deep muscle the implanted wire electrode [2]. This method is targeted and is a very important significance for abnormal gait, nerve and muscle of specific causes. But since the high check cost, it is difficult to be widely accepted.

1.2.5. Oxygen consumption

To analyze of human walking energy consumption, subjects should wear a portable oxygen analyzer. The exhaled gas should be

collected during walking to do oxygen consumption analysis which be to do division with the walking distance: the lower the oxygen cost, the smaller the energy consumption for walking [9]. It is often used to detect the oxygen consumption during walking under prostheses, orthoses or various pathological conditions [2]. It can be used as a sensitive indicator for assessment of rehabilitation efficacy and brace usage. The gold standard for any walking training is to reduce the effect of oxygen consumption, therefore, the oxygen consumption will be a very promising technique in the future [10].

2. Clinical application

Many damaged systems will result in gait abnormalities, such as the nervous system, musculoskeletal system, etc. [2]. Gait analysis has an important role in the cause analysis and diagnosis of human motion and nervous system disease, and in the assessment of interventions [11]. Rosano et al [12] have done the gait analysis and MRI on the 220 elderly over the age of 65 within 3 years in four medical centers. All the elderly could walk independently and did not receive cancer therapy. MRI results of functional areas of the cortex and space-time variables measured by Gaitmat II from the multiple linear regression model have been analyzed that the shortening of step length and the extending of feet support time are related to the decreasing of sensorimotor area and the reducing of the amount of movement, vision and cognitive areas of the parietal bone, and these are independent of other risk factors (peripheral nerve disease, brain structure abnormalities and obesity, etc.) of gait. More results have been concluded that early interventions in cardiovascular drugs and exercise can delay the process of brain structure atrophy for the elderly and the related motor function.

Parkinson's disease (PD) is a common neuromuscular diseases. Movement disorders in particular gait disorders are the main features. Roiz R. M. et al [13] have used 3D motion analysis system to do gait analysis and comparison in 12 patients with congenital PD and 15 healthy human. They have found that compared with healthy people, PD patients have the reduced stride length, the slowed down pace and the limited lower extremity range of motion. The slow walking speed and the reduced stride length have been analyzed in relationship. This is inconsistent with previous studies which have regarded the slow walking speed to be related with the stride frequency. This may be in relevant to the inconsistent disease process.

Gait analysis used in the sports medicine and the sports injury can help to make clear the mechanism of the athletic injury and to prevent and reduce injury. Li Feng et al [14] have analized the plantar pressure distribution of 30 healthy fencers under the normal walking and the lunge using the F-scan system. Under the lunge, the torque force generated by the exessive varus/valgus of the foot at the very moment of the heel against the ground may be one of the reasons leading to the chronic knee injury. And they also proposed the mothod expectedly to prevent knee injury.

With the development of gait analysis, it is playing an increasingly important role in the diagnosis and treatment of cerebral palsy. The analysis results from Li Hai et al [15] in 78 normal children and 25 cases of cerebral palsy children based on the gait plantar pressure analysis system have shown that, compared with normal children, young children with cerebral palsy has smaller step frequency and longer period; the absolute symmetry index (ASI) of the single-foot support time, the swing time, the feet support time and the gait cycle time are all significantly higher than normal children. The research of Bell et al [16] on 8 cases of children with cerebral palsy has also suggested that, without surgical intervention, the walking function of children with cerebral palsy has decreased significantly.

Ankle foot orthotics (AFO) has been often used to improve the gait in hemiplegic patients. It can assess the effectiveness of patients walking by comparing the gait before and after installation of AFO. Nolan [17] has once assessed the effect of AFO in the continuous 10 months on a right side hemiplegia patient after one month of a stroke. The stride length and the walking speed have been increased significantly. The step width and the feet support time have been reduced significantly., And the moving angle of the hip joint in the swing phase has been increased. These illuminate that AFO has increased the stability of the ankle during the walking, and improved the hemiplegic gait. It needs more study in the future on the hemiplegic patients of different ages with AFO.

3. Outlook

Walking gait is the feature for the human behavior. The normal walking involves the coordination and the coorperation of multiple systems. If the lesions occured in the bone, the nerve or the muscle system, it is easy to show in the gait. Therefore, it has very important significance to apply the gait analysis to the clinical diagnosis and the disease assessment of the skeletal, the nervous and the muscular system

With the development of gait analysis, it has developed from the initial visual method for the present three-dimensional analysis way. 3D gait analysis system can objectively and quantitatively

assess the walking function of the human body. The system consists of photovoltaic systems including reflective landmarks, electromyography systems and synchronous video system. The testing accuracy and reliability has been greatly improved compared with the visual observation and the footprints method, and has been appled all over the world. But this system is complicated and requires a strong professional that, for the expensive, yet it has not universally applied in clinic in China. Because of the simple and easy to get unlimited by the equipment, operating and other conditions, the footprints and the visual methods, are still used on clinic in China [7]. Although some units have developed a few gait analysis systems, but standards are not uniform [18-19]. Thus, the domestic clinical needs a simple, sensitive, accurate and more uniform standard gait analysis system. It is sure that, with the rapid technological development, the operating system for gait analysis will be improved toward the direction of more intelligent, portable and accurate. And the gait analysis technology will also become more widespread. If it selected the targeted analysis method based on the patient's specific circumstances and various characteristics, perhaps it could provide more effective help about the clinical individual rehabilitation programs development and the rehabilitation efficacy assessment.

It also can be a useful technique for the scene reconstruction in forensic sciences.

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