VISUAL CHANGES IN GAIT IN INDIVIDUALS WITH PARKINSON DISEASE

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Abstract: Gait is a pattern of how a person walks. It is the movement of human limb resulting in locomotion. Parkinson's disease damages the neurons that produce dopamine, a neurotransmitter that transmits signals to the different parts of the brain. Shortage of dopamine is a cause of Parkinson disease where the person loses the ability to execute smooth and controlled movement. Dopamine controls our movements and reduction in dopamine results in motor deficit. Gait analysis gives an idea about the neurological condition of a person. Parkinson gait causes the head and neck muscle to move to the front giving stooped posture, with visible symptoms like slowness of movement, small shuffling steps, reduced walking speed mainly due to muscle hyper tonicity. This paper discusses about gait, its phases and gait disorders related to neurological problem.

Keywords: Dopamine, gait, hyper tonicity, kinematics, electromyography

I. INTRODUCTION

Parkinson's disease is the largest neurological disorder next to Azhielmer's disease that targets neurons which produce the dopamine chemicals. The dopamine generating cells called dopaminergic neurons in substantia nigra (nucleus in the mid brain which is a part of basal ganglia) and prefrontal cortex (frontal lobe) part of the brain which is responsible for coordination and movement dies. This causes motor deficits. The patient involuntarily moves with short, accelerating steps, often on tiptoe, with the trunk flexed forward and the legs flexed stiffly at the hips and knees [1]. It is seen in Parkinson's disease and affects the basal ganglia. This is also called as festination.

II. GAIT PHASES

Gait is the pattern of how a person walks. Gait cycle is the series of events that occur from heel strike of one limb to next heel strike of the same limb. Gait has two phases. The stance phase forms 60% of gait cycle and swing phase forms 40% of gait cycle [2].

The normal forward step consists of two phases:

- The stance phase where the foot is in contact with the ground. It begins when the heel strikes the ground and ends when the toe of the same foot is off from the ground. Here one leg and foot are bearing most of the body weight.
- The swing phase where the foot is not in contact with the ground. It begins when the foot leaves the ground and ends when the heel of the same foot strikes the ground. Here the body weight is borne by the other leg and foot.
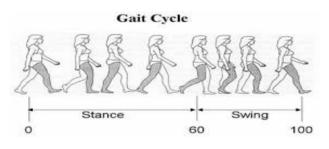

Figure 1: Gait Cycle

In a complete two-step cycle, both the feet's are in contact with the floor for about 25 per cent of the time. This part of the cycle is called the double-support phase [3].

III. GAIT EVALUATION

Parkinson gait disturbance can be either continuous appearing when the patient walks or episodic lasting for few seconds [4].

People with Parkinson disease experience gait impairment as the disease progress. There are different ways to evaluate gait. Some of the ways are

- A. Taking video to record the images of patient during walking
- B. Capturing motion to digitally track patient movement
- C. Using force plate to measure ground reaction force
- D. EMG to record muscle activity during gait

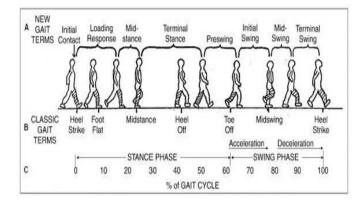Gait is evaluated by letting the individual to walk in a straight line.

Figure 2: Gait terms [5]

IV. GAIT ANALYSIS

Gait analysis is divided into three fields: Gait kinematics, Gait kinetics and electromyography(EMG) [6]. The kinematics of gait record the movement of major joints of lower extremity in the human gait and describe the motion such as length, velocity, acceleration. Gait Kinetics is the study of forces and actions in the production of human movement and requires the orientation of all the leg segments obtained in gait kinematics. It deals with the causes of motion such as force, work, energy and power. EMG of human gait involves detecting and analyzing muscle activity during walking.
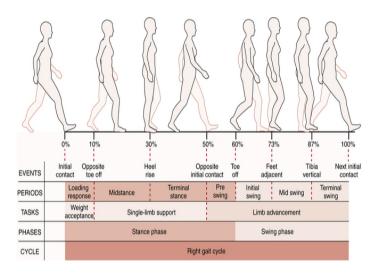

Figure 3: Detailed Gait Task [7]

An analysis of each of the component in the three phases of ambulation is an important step in the diagnosis of various neurologic disorders.

Table 1: Gait Cycle task

Cycle Phase	Period	Comment
Stance phase (60%)	Contact	From the time heel strikes to foot flat. Here the foot act as a shock absorber and adapts to the irregularities in the ground surface.
	Midstance	From the time foot is flat to heel lift. Here the total weight of the foot is in contact with the Ground.
	Propulsion	From the time heel is lifted to toe off. Here the foot act as a rigid and stable lever.
Swing phase (40%)		From the time the toe is off the limb 1 to heel strike of limb 1. Here the body mass transfers from limb 1 to limb 2.

V. PARKINSON'S DISEASE

Parkinson disease is a progressive disorder and the symptoms tend to increase with time. Parkinson gait causes the head and neck muscle to move to the front giving stooped posture, with visible symptoms like reduced arm swing, slowness of movement, small shuffling steps, reduced walking speed mainly due to muscle hyper tonicity [8].
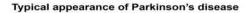

Figure 4: Parkinson Gait

There are different scales available to categorize Parkinson disease with regard to their severity of motor symptoms. Some of them are [9]:

A. Hoehn and Yahr scale (H&Y):
This scale ranges from one to five, where a higher H&Y score signifies a more severe disease stage. Scale 1 indicates unilateral involvement, 2 indicates bilateral involvement, 3

indicates the stage when the disability begins, 4 indicates severe disability and 5 indicates bedridden stage.

B. Unified Parkinson disease rating scale (UPDRS):

This scale entails four parts: part I concerns mentation, behaviour and mood; part II concerns activities of daily living; part III investigates motor symptoms; and part IV focuses on complications.

C. Multiple Sclerosis Functional Composite (MSFC):

MFSC comprises of Nine-Hole Peg Test (an arm dexterity measure), a timed 25-foot walk (a gait assessment), and the Paced Auditory Serial Addition Test (PASAT) which are cognitive measure. The Total MSFC is the composite of the three tasks and this test is better compared to UPDRS.

Other scales used in measurement of gait are as follows:

A. The Mini-BESTest:

The Mini-BESTest is a clinical tool, stated to measure dynamic balance. This test encompasses 14 items, divided into the four subcomponents: anticipatory postural adjustments, postural responses, sensory orientation, and dynamic gait. Items are scored from 0 (unable or requiring help) to 2 (normal) on an ordinal scale, with a maximal total score of 28 points.

B. The Mini-Mental State Examination score:

The Mini-Mental State Examination score (MMSE) is test of cognitive function, stated to cover areas such as orientation, registration, attention and calculation, recall and language. This test entailing 11 items, is evaluated based on a total score. The maximal score is 30 of which a score below 24 is considered an indication of Parkinson Disease.

C. The timed up and go test:

The timed up and go test (TUG) is a clinical test evaluating the construct of physical mobility, and has been found reproducible and valid in Parkinson Disease. The test itself measures the time it takes for a subject to perform the following sequence: stand up from a standard arm chair, walk a distance of 3 meters, turn 180 degrees, walk back to the chair, and sit down again.

D. The GAITRite electronic walkway system:

The GAITRite system is a nine metre electronic walkway that is connected to a computer. The walkway has embedded pressure sensors that allow for the detailed investigation of specific gait parameters and is used to indicate Parkinson Disease.

VI. ABNORMAL GAIT CHARACTERISITICS IN PARKINSON PATIENT

Parkinson's disease patient show gait characteristics that are different from normal gait.

A. Heel to toe characteristics:

In normal gait, the heel touches the ground before the toes. This is called heel-to-toe walking. In Parkinsonian gait, the entire foot is placed on the ground at the same time. This is called flat foot strike. In the advanced stages of the disease, the toes touch the ground before the heel. This is called toe-to-heel walking. PD patients do not lift their foot completely.

There is reduced space between the toes and the ground and thereby exhibit reduced foot lifting during the swing phase of gait. This is the main cause for postural imbalance.

B. Vertical ground reaction force:

In normal gait, the vertical ground reaction force plot has two peaks. The first peak occurs when the foot touches the ground and the second peak is due to push-off force from the ground. In Parkinsonian gait, the shape of the vertical GRF signal is abnormal. Since their heel does not touch the ground first and they do not lift their foot completely, there is reduced force (or peak height) for the heel contact and the push-off phase. In the advanced stages of the disease, gait is characterized by small shuffling steps. PD patients show only one narrow peak in the VGRF signal.
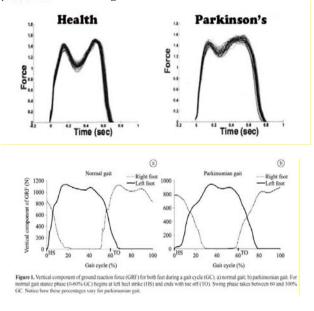

Figure 5: Ground Reaction Force

C. Falls and freezing of gait:

Falls and freezing of gait are two episodic phenomena seen in Parkinsonian gait. They are more common in the advanced stages of the disease. Sometimes freezing of gait leads to falls.

1. *Falls:* Falls occur on rising from chair or bed due to change in posture or turning movements of the trunk. It can be seen when the individual performs more than one activity simultaneously while walking or balancing. 45% of all falls occur in forward direction whereas 20% fall laterally.

2. *Freezing of Gait:* Freezing of Gait(FOG) is defined as the inability to make effective steps. FOG lasts less than a minute. Here the gait is halted and the individual feels that the feet is stuck to the ground. When the patient overcomes this, walking can be performed easily.

D. Postural imbalance:

Postural imbalance is the inability to maintain balance while walking, standing and during other upright activity. It is more visible in the advanced stages of PD. Lack of flexibility of the body in response to shifting postural movement results in postural instability and increases the tendency to fall in patients.

E. Electromyographic studies:

Electromyographic studies(EMG) of the leg muscles in Parkinson patients shows prolonged activation in the stance phase of the gait. They have higher stiffness of the ankle joints and show large EMG activity and more co-contraction of leg muscles in the stance phase. Stiff joints lead to abnormal posture in the PD patients.

VII. ATTRIBUTES IN GAIT MEASURE

Following parameters are measured during gait

1. Stance time:
Stance time is the time when foot is on the floor.

2. Swing time:
Swing time is the time when foot is in the air.

3. Step length:
Step length is the distance between heel strike of one limb to the heel strike of the other limb.

4. Stride length:
Stride length is the distance between successive heel strike of one limb to heel strike of the same limb. It is the sum of two consecutive step length.

5. Cadence:
Cadence measures the speed of gait. It is the number of steps for a period of time. The longer the gait period, slower is the cadence. As cadence increases, the time of double support decreases.

6. Gait cycle:
Gait cycle is the time between two consecutive heel strike of the same foot.

7. Step time:
Step time is the time between heel strike of one limb to the heel strike of other limb.

8. Stride time:
Stride time is the time between successive heel strike of one limb to the next heel strike of the same limb. It is the time taken for a full gait cycle.

9. Average gait velocity:
Average gait velocity is the stride length divided by stride time.

10. Variability:
Variability is the coefficient of variation(CV).

$$CV = 100 * \frac{standard\ deviation}{mean}$$ of the swing time

VIII. CONCLUSION

Basal ganglia, the primary area of impairment in PD, resulting in gait disorders were identified. The attributes to identify gait in Parkinson's disease were discussed. As the disease progresses, motor complexities and disability increases reducing the quality of life of the patient. It increases the economic burden of the patients and also the healthcare costs of the country. At present, there is no cure available for the disease, but when identified earlier, its symptoms can be controlled and quality of life can be improved by taking various treatments available today. So, it's very important to get Parkinson's disease diagnosed as soon as possible and start taking preferred treatments to maintain a good quality of life. Thus these gait attribute help to identify the Parkinson patient and also serves as a clinical tool to identify the disease.

IX. ACKNOWLEDGMENT

X. REFERENCES

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