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Review Article

Turning deficits in people with Parkinson's disease

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ABSTRACT

More than half of people with Parkinson's disease (PwPD) report difficulty when turning, which has significant implications for their risk of falling. Turn steps, turn time, turn type, and turn quality are key elements that could be observed in a video-based clinical assessment. This assessment could be carried out at home with video cameras that are simple to operate and easy to obtain. A laboratory-based examination investigates quantitative and kinematic data, such as the onset time of the head, trunk, pelvis, and leg, and the amplitude of angular rotation and relative rotation angles between different segments of the body in both the roll and yaw planes. PwPD take more steps, have a longer turn time, and use less efficient turn types, such as delayed onset, incremental, and larger turning-arc turn types, to complete a turn than unaffected individuals. They display instability, use of support, lack of ground clearance and lack of continuity during a turn. Poor intersegmental coordination and slower and smaller rotations of the head, trunk, and pelvis are also observed in turning. Increased postural tone, axial rigidity and loss of intersegmental flexibility may contribute to an *en bloc* turning strategy. Impaired motor planning, bradykinesia, and freezing make it difficult for PwPD to switch from one motor program (turning) to another (walking). Clinicians should examine patients' turning capacity during a routine movement evaluation and note any complaints about difficulties in turning. Testing of turning tasks needs to be done on both sides and related to real-life experience. Therapists should assist PwPD to find adaptive strategies, such as home modification and compensatory strategies while turning. Rehabilitation programs should focus on enhancing balance training and axial mobility.

1. Introduction

Parkinson's disease (PD) is a chronic, progressive, degenerative disorder of the central nervous system [1]. The prevalence rate is 340/100,000 in Taiwan [2], but varies worldwide from 18/100,000 (Shanghai, China) to 328/100,000 (Bombay, India) [3]. The incidence rate in Taiwan has been assessed as 345 in every 100,000 people [2] and as 5–346 out of every 100,000 people in European countries [4]. The average onset age is 55 years, and it is slightly more common in men than women [5]. The onset of PD is associated with a degeneration in the basal ganglia and substantia nigra, which produce dopamine, a neurotransmitter that sends signals to the brain. When dopamine-producing cells die, the brain's ability to communicate internally is seriously affected, which results in problems with regulation and control of physical movements [6].

Movement disorders are among the key impairments of PD and can severely influence motor abilities such as walking, writing, turning around, and getting in and out of bed [7]. A high percentage (52–62%) of people with PD (PwPD) report difficulty when turning [8], which is associated with falling and freezing of gait [9] and has a significant effect on quality of life [10]. At least two turns every 10 steps are performed in daily activities [11]. However, the studies investigating nonlinear movement, such as turning or transferring, are relatively few in comparison with those investigating linear movements such as walking and moving from sitting to standing.

2. The methodological issues in assessing turning in PwPD

Assessment of turning is embedded within a larger scale assessing balance, and is not a major item in a regular physical therapy evaluation. Clinicians may assess turning by performing the timed up-and-go test, which includes a 180° turn [12], or with the Berg balance scale [13] or the Tinetti motor assessment [14], both of which include a 360° turn. The number of turn steps and the duration of turn time are commonly measured. Investigations of

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turning in the existing literature can be categorized into two approaches: clinical assessment and laboratory-based examination. Turning tasks can be an on-the-spot 180° turn [11,15], turning 180° from a standing start [16,17] or turning 60°/90°/120°/180° while walking [15,18–23].

Clinical assessment of turning is mostly carried out using a video camera [15–17]. The turn steps, turn time, turn type, and turn quality are usually the key elements observed. The strength of this clinical assessment is that videos can be reviewed and discussed after recording. The test can be carried out at home, in a clinical setting, or in a laboratory, with video cameras that are simple to operate and easy to obtain. Special training and knowledge are not needed, and the assessment is suitable for all allied health professionals. However, a shortcoming of this type of assessment is that only descriptive data can be gathered and analyzed because of the limitations of a naked eye observation compared with a laboratory-based examination.

A three-dimensional motion capture system [18–23] is the most common equipment used to analyze and examine the kinematics of movement. Studies usually examine the onset time of movements of the head, trunk, pelvis, and leg, and determine the amplitude of angular rotation and relative rotation angles in both the roll and yaw planes between different segments of the body. Although quantitative data can be collected by laboratory-based methodologies, these all require sophisticated and highly technical facilities and equipment in a laboratory. Such data are therefore difficult to collect at home or in a clinical setting, and they also lack ecological validity. Movements performed by patients in a laboratory may be different from the same movements in their home environment because of the unfamiliar context and equipment fitted on the body.

3. Turning characteristics in PwPD

Healthy people used fewer turn steps (2–3 steps) and less turn time (<2 seconds) to complete a 180° turn than PwPD [16]. They also used types of turns with few steps, such as toward (one foot is moved ipsilateral to the turn direction and the other foot advances directly toward the target), pivotal (2–3 steps with wider steps), and lateral types (2–3 steps with the first foot being moved contralateral to the turn direction) while turning [16]. Normally, a top-down segmental approach is used to reorient the body to a new direction. In this strategy the head rotation precedes shoulder rotation, which in turn precedes pelvic rotation [24]. However, PwPD take more turn steps (>4 steps) [11,15], have a longer turn time (>2 seconds) [19,20] and a smaller step width [25] in completing a 180° turn than unaffected individuals. The longer duration is especially significant for the first turn step [20], indicating that PwPD experience greater difficulty in initiation than in termination of turns. They also tend to use less efficient turn types—delayed onset (initial steps making a negligible direction change and advance) [16]; incremental turns (multiple turning steps on-the-spot prior to advancing to the target) [16]; and a larger turning-arc (increased width, length, and distance of arc) [18]—and show worse turn quality (instability, use of support, lack of ground clearance, pause during or after turning) in completing turns [15,17,18]. Increased delay in head reorientation in the new direction and smaller intersegmental movement between the head and truck as an *en bloc* strategy have been observed in PwPD [20–22]. They also display slower and smaller rotations of the head, trunk, and pelvis and lower peak trunk yaw and roll angular velocities [11,23]. PwPD have difficulty in achieving minor changes in direction, even in making small turns of 30° while walking [25]. These turning problems can be observed in all stages of PD, even the early stage when marked functional deficits are not typically present [26]. Additionally, PwPD with more severe symptoms [15], poorer balance and functional ability [27], a freezing gait [28], or a history of falling [15], have worse performance when turning.

There is still no clear mechanism for interpreting turning deficits in PwPD. Marsden and Obeso [29] believe that turning while walking is affected by impaired motor planning, and PwPD have difficulty in changing from one motor program (walking) to another (turning) [5]. Bradykinesia can interfere with turning at the beginning of a task, such as an on-the-spot 180° turn or turning from a standing start, causing a longer turning time and requiring more steps to be taken [7]. In addition, increased postural tone, axial rigidity, and loss of intersegmental flexibility can be causal factors that result in fixed turning in PwPD [22,30]. Taking more steps over a longer time to complete a turn is an expression of turning difficulty in PwPD, but it might also be a strategy for compensation and adaptation to provide more postural stability and reduce the risk of freezing [18]. Shorter steps and a slower gait speed are both walking characteristics among PwPD [7], so it is not surprising to observe similar features in turning.

4. Clinical implications

Past studies have emphasized walking in a straight line as an experimental task [7], and therapists have done few evaluations of movement performance when turning in a clinic. The present review paper shows that PwPD, especially those with a severe presentation of the syndrome, have poorer turning movements than age-matched unimpaired older people [15–23]. Therefore, clinical therapists should examine turning capacity during routine movement evaluations and note any complaints about difficulties in turning. It would be helpful to have simple tools to detect turning difficulties, which are related to risks of falling [9]. Brief clinical assessments of turn steps, time, type, and quality might give clinicians some insight. When therapists assess turning ability, the conducted task should mimic daily activities as far as possible—such as carrying a book when turning—in order to test real situations and abilities. It is necessary to examine turning to both sides because early-stage PwPD mainly have one-sided body involvement.

However, fewer turning steps and reduced turn time are not set as treatment goals in rehabilitation programs. Normalizing the turning performance of PwPD to that of healthy people might increase their risk of falling, so therapists should assist PwPD in finding an adaptive strategy. First, the environment may be modified to decrease the need for turning. Second, a compensatory strategy while turning should be provided, such as the use of support, lifting the foot clear, taking time to turn, and stepping more, rather than swiftly changing direction [17]. Concentrating on turning in a wider arc and a larger space using whole-body movements can overcome freezing during a turn [31]. The “clock turn” strategy is recommended when turning in a very small space [32]. The person thinks of the right foot as being in the center of a circle, with the left foot stepping around the circumference, or *vice versa*. For example, an individual consciously thinks of stepping to mimic the movements of a clock; the right foot remains stable on the ground while the left foot moves to 12 o’clock, 2 o’clock, and 4 o’clock while turning 180°.

Axial rigidity and loss of intersegmental flexibility can be factors that cause fixed turning in PwPD [22], and therefore therapeutic exercise should focus on enhancing balance training and axial mobility. External stimuli, such as visual and auditory cues, have been reported to enhance reaction time and reduce freezing during turning [18,33]. However, these effects disappear after cue removal, which raises questions regarding the influence of training on cue dependency [33]. In one study, anti-Parkinson medications reduced

the turn time and steps, and slightly increased the amplitude of yaw rotation of body segments, but did not improve the *en bloc* turning strategy, suggesting minimal improvement in turning. However, further studies are needed because this study was the first to examine the effects of medication on turning and it had a small sample size [34]. Combining a pharmacological approach with rehabilitative exercise might be a more effective way to improve turning difficulties in PwPD.

5. Conclusions

The majority of PwPD have difficulty in turning, which has a clear association with the risks of falling and a significant impact on quality of life. Video-based clinical assessment and laboratory-based examination have shown that PwPD take more steps, spend more time, use less efficient turn types, and show poor quality in completing turns. Poor intersegmental coordination as well as slower and smaller rotations of the head, trunk, and pelvis cause an *en bloc* turning strategy and lead to potential disequilibrium during turning. It is suggested that turning tasks are added to routine physical therapy evaluations. PwPD who report or show turning difficulty should be screened, and rehabilitation programs tailored to their needs.

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