

■ ORIGINAL ARTICLE

Factors determining the duration of retaining gait independence in movement disorders: Importance of clinical diagnosis

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ABSTRACT: Although factors involved in maintaining gait independence can be predicted to some extent based on clinical experience, they have not been described scientifically or statistically, and it is difficult to predict the duration of retaining gait independence from clinical experience. Thus, we attempted the scientific and statistical extraction of factors determining the duration of retaining gait independence from UPDRS of movement disorders and prepared a calculation model to predict the duration using the extracted factors, aiming at applying it to plan physical therapy and life activities. Clinical diagnosis, rigidity, leg flexibility, and orthostatic hypotension were extracted as factors determining the duration of retaining gait independence. For physical therapists who predict the duration of retaining gait independence, plan physical therapy, and advise patients in life planning, accepting the clinical diagnosis made by medical doctors (MD) without question, the finding that the clinical diagnosis was included in the factors reconfirmed its importance.

Key words: Movement disorder, Clinical diagnosis, Gait

INTRODUCTION

It is very important to be able to present how long patients will retain gait independence and factors involved in prolonging it as much as possible for not only those with movement disorders, including Parkinson's disease, but also persons taking care of them and physical therapists to plan physical therapy and life activities in the future. Factors maintaining gait independence can be predicted to some extent based on clinical experience, but they have not been described

scientifically or statistically, and it is difficult to predict the duration of retaining gait independence from clinical experience. Thus, we extracted factors determining the duration of retaining gait independence in movement disorders from the Unified Parkinson's Disease Rating Scale (UPDRS) both scientifically and statistically, and constructed a calculation model to predict the duration using the extracted factors, aiming at its application to plan physical therapy and life activities.

$$\begin{aligned}
 h1 &= (\text{Bias } 1) + (\text{Weight1_ Predictive factor } 1) + (\text{Weight2_ Predictive factor } 2) + \dots \\
 H1 &= \tanh(h1) \\
 h2 &= (\text{Bias } 2) + (\text{Weight3_ Predictive factor } 1) + (\text{Weight4_ Predictive factor } 2) + \dots \\
 &+ (\text{Weight5_H1}) \\
 H2 &= \tanh(h2) \\
 h3 &= (\text{Bias } 3) + (\text{Weight6_ Predictive factor } 1) + (\text{Weight7_ Predictive factor } 2) + \dots \\
 &+ (\text{Weight8_H1}) + (\text{Weight9_H2}) \\
 H3 &= \tanh(h3) \\
 \text{OUT} &= (\text{Bias } 4) + (\text{Weight } 10_ \text{Predictive factor } 1) + (\text{Weight } 11_ \text{Predictive factor } 2) \\
 &+ \dots + (\text{Weight } 12_ \text{H1}) + (\text{Weight } 13_ \text{H2}) + (\text{Weight } 14_ \text{H3}) \\
 \text{Independence Period} &= \text{Transfer function } f(\text{OUT})
 \end{aligned}$$

Fig.1 A prediction model of gait independence period by NNW

Table 1 The factor which prescribes gait independence period by NNW

Base data			UPDRS						
Sex	Age	Clinical diagnosis	Intellectual impairment	Thought disorder	Depression	Motivation/ Initiative	Speech	Facial expression	
		○							
UPDRS									
Tremor at rest					Action or postural tremor of hand		Any sleep disturbances, such as insomnia or hypersomnolence?	Does the patient have symptomatic orthostasis?	
Head	Left upper extremities	Right upper extremities	Left lower extremities	Right lower extremities	Left hand	Right hand			
								○	
UPDRS									
Rigidity					Finger taps		Hand movements		
Neck	Left upper extremities	Right upper extremities	Left lower extremities	Right lower extremities	Left finger	Right finger	Left hand	Right hand	
○	○	○	○	○					
UPDRS									
Rapid alternating movements of hand		Leg agility			Arising from chair	Posture	Gait	Postural stability	Body bradykinesia and hypokinesia
Left hand	Right hand	Left leg	Right leg						
		○	○						
UPDRS									
Dyskinesia			Clinical fluctuations					Does the patient have anorexia, nausea, or vomiting?	
Duration	Disability	Painful dyskinesia	Presence of early morning dystonia	Are off periods predictable?	Are off periods unpredictable?	Do off periods come on suddenly?	What proportion of the waking day is the patient off on average?		

SUBJECTS AND METHOD

The subjects were 22 patients with movement disorders undergoing physical therapy. There were 11 males and females, aged 71.3 ± 9.5 years on average. The clinical diagnosis was progressive supranuclear palsy (PSP)¹⁻³ in 7, corticobasal degeneration (CBD)⁴ in 8, multiple system atrophy-Parkinsonian (MSA-P)⁵ in 1, Parkinson's disease with dementia (PDD)⁶ in 3, dementia with Lewy bodies (DLB)⁶ in 2, and Parkinson's disease (PD)⁶ in 1. We constructed a Learning Internal Representation by Error Propagation of Neural Network (NNW)⁷, regarding the gender, age, clinical diagnosis, and measured UPDRS (Parts 1, 3, and 4) as input variables, and the time (number of months) after the gait condition came to require assistance, i.e., the time (number of months) after the gait score of the Barthel Index (BI) decreased to "10" from "15", as a target variable (BI was adopted, instead of UPDRS Part 2, for the evaluation of activities of daily living (ADL) as a parameter of the target variable), and extracted factors determining the duration of retaining gait independence. The duration was calculated using the duration-predicting model (Fig. 1) constructed through the above process.

This study was performed in conformity with the Declaration of Helsinki after explaining its objective to and obtaining written consent from the subjects.

RESULTS

Factors determining the duration of retaining gait independence extracted from the constructed NNW were the clinical diagnosis, rigidity, leg flexibility, and orthostatic hypotension (Table 1). The mean duration of retaining gait independence (months) in the 22 patients calculated employing the prediction model (Fig. 1) by disease was 65.3 ± 24.3 months in 7 PSP patients, 44.4 ± 14.2 months in 8 CBD

patients, 24.1 months in one MSA-P patient, 27.0 ± 0.8 months in 3 PDD patients, 26.6 ± 0.4 months in 2 DLB patients, and 25.7 months in one PD patient (Table 2).

Table 2 Several month average of gait independence by NNW

Clinical diagnosis	Number of subjects	Gait independence period in a calculation by NNW (month \pm SD)
PSP	7	65.3 ± 24.3
CBD	8	44.4 ± 14.2
MSA-P	1	24.1
PDD	3	27.0 ± 0.8
DLB	2	26.6 ± 0.4
PD	1	25.7

DISCUSSION

Of the extracted factors determining the duration of retaining gait independence in movement disorders, rigidity, leg flexibility, and orthostatic hypotension are easily understandable. The extrapyramidal system and cerebellar circuit are impaired in many movement disorders, and the autonomic nervous system is also influenced. Rigidity represents enhanced physiological muscle tonus induced by impairment of the cortico-basal ganglia loop, and patients lose their walking ability and readily fall due to the narrowing of the range of joint movement while walking and impairment of fine postural control. Regarding leg flexibility, impairment occurs due to rigidity associated with the impaired extrapyramidal system, but the balancing ability also declines due to reduced muscle coordination in disorder of the cerebellar circuit, leading to unstable gait. Of the diseases, DLB, PDD, and PD are Lewy body disease (LBD)⁶, in which the presence of Lewy bodies associated with α -synuclein abnormality

is suspected. In LBD, Lewy bodies, i.e., neurodegenerative regions, not only exist in the midbrain, basal ganglia, cerebral cortex, and sympathetic ganglion of the heart but also disseminate to the intermediolateral nucleus of the spinal cord (IML). This region is involved in autonomic nerve regulation, and it is understandable that orthostatic hypotension influences walking.

The point to pay attention to is that clinical diagnosis was extracted as a factor determining the duration of retaining gait independence in movement disorders, indicating that the duration varies among clinical diagnoses. For physical therapists who predict the duration, plan physical therapy, and advise patients on life planning, accepting the clinical diagnosis made by MD without question, this finding reconfirms the importance of the clinical diagnosis. It does not mean questioning clinical diagnoses made by MD, but if the duration of retaining gait independence varies depending on the clinical diagnosis, actions taken based on acceptance of clinical diagnoses made by MD without question should be reflected, and physical therapists should carefully investigate the accuracy of the clinical diagnosis with regard to prediction of the duration of retaining gait independence in cooperation with MD.

It should be thoroughly considered that an accurate clinical diagnosis leads to an accurate functional prognosis, and results in realistic life planning for patients. MD should not make a clinical diagnosis as their exclusive task or right. They should acquire necessary information from appropriate medical staff and cooperatively make an accurate clinical diagnosis, which optimizes treatment for patients.

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