The Nutritional Status of Elderly Chinese Patients With Parkinson's Disease

Gerontology & Geriatric Medicine
Volume 10: 1–7

Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/23337214241284181
journals.sagepub.com/home/ggm
Sage

Sheng Wu, MD[1], Peng Liu, MD[2], Xiulin Tian, MSc[1], Bo Wang, MD[1], Zhiyuan Ouyang, MD[1], and Wei Luo, MD[1]

Abstract

Introduction: To investigate the nutritional status of elderly Chinese patients with Parkinson's disease (PD) and analyze possible factors related to nutritional problems. **Methods:** Patients with PD aged 65 years or older were enrolled. Anthropometric assessment and Mini Nutritional Assessment were used to determine nutritional status. Various scales were completed to identify potentially related factors, such as Hoehn and Yahr stage (H&Y stage), 30 mL water swallow test, Clock Drawing Test (CDT), and Charlson Comorbidity Index (CCI). **Results:** 785 patients were enrolled. The prevalence of malnutrition and risk of malnutrition was 3.1% (24/785) and 25.7% (202/785), respectively. Regression analyses indicated that H&Y stage $\geq$ 3 (OR: 2.151; 95%CI: 1.174–3.941; $p = .013$), abnormal water swallow test (OR: 4.559; 95%CI: 2.130–9.759; $p < .001$), CDT score < 6 (OR: 2.810; 95%CI: 1.534–5.148; $p = .001$), and CCI (OR: 1.621; 95%CI: 1.238–2.124; $p < .001$) were considered to be potential factors associated with low BMI. **Conclusion:** 28.8% of elderly PD patients were in abnormal nutritional status. Disease severity, dysphagia, cognitive function, and comorbidities might be related factors.

Keywords

Parkinson's disease, malnutrition, Mini Nutritional Assessment, Clock-Drawing Test, risk factors

Manuscript received: May 31, 2024; **final revision received:** July 27, 2024; **accepted:** August 28, 2024.

Introduction

Parkinson's disease (PD) is a neurodegenerative disorder characterized by loss of dopaminergic neurons in the substantia nigra, leading to motor and non-motor symptoms (Rai & Singh, 2020). The prevalence of PD for individuals aged 65 or older is 1.7% in China (Zhang et al., 2005). It was predicted that by 2030, there will be 5 million PD patients in China, more than half of the world's total (Dorsey et al., 2007).

Over the last few decades, clinicians and researchers have recognized most of the symptoms of PD and the corresponding treatment and interventions have become commonly used in clinical practice. Since the 1990s, several studies have focused on the nutritional problems of patients with PD. It was found that patients with PD experienced significantly more weight loss and malnutrition than age-matched healthy controls (Beyer et al., 1995; van der Marck et al., 2012). According to a systematic review, the prevalence of malnutrition in patients with PD ranged from 0% to 24%, while risk of malnutrition ranged from 3% to 60% (Sheard et al., 2011). Such wide variations were due to differences in assessment tools and sampled populations. Malnutrition may impact PD progression, especially among the elderly, giving rise to dyskinesia, cognitive decline, orthostatic hypotension, and resulting in lower quality of life, even disability and mortality (Ma et al., 2018).

Up to now, the nutritional status of elderly patients with PD remains poorly understood. The precise incidence of malnutrition and the associated factors remain unclear due to limited large sample studies and comprehensive analyses. Consequently, nutrition issues often go unnoticed and receive inadequate treatment. The objective of this study is to assess the nutritional status of elderly Chinese patients with PD through a comprehensive cross-sectional analysis of a large sample, identify potential associated factors, and provide precise clinical information for future intervention studies.

[1]Second Affiliated Hospital of Zhejiang University, Hangzhou, China
[2]Taizhou Central Hospital, China

Corresponding Author:
Wei Luo, Department of Neurology, Second Affiliated Hospital of Zhejiang University, 88 Jiefang Road, Hangzhou 310009, China.
Email: luoweirock@zju.edu.cn

Methodology

Subjects

In this multi-center cross-sectional study, a total of 785 consecutive patients (aged ≥ 65 years) diagnosed with idiopathic PD were recruited between December 2019 and December 2022 from four hospitals in Zhejiang Province, China: the Second Affiliated Hospital of Zhejiang University (Jiefang Campus), Binjiang Hospital, International Medical Center, and Taizhou Central Hospital. The diagnosis was made according to the clinical diagnostic criteria of the Movement Disorder Society (Postuma et al., 2015). Patients with other types of parkinsonism or those unable to complete the questionnaires were excluded from the study. All patients were evaluated and followed by movement disorder specialists.

Assessment

Demographic data (age, sex, years of education), disease duration, and the details of patients' current therapies (medication, surgical treatment, and rehabilitation) were collected using a specially designed questionnaire.

Nutritional assessments included anthropometric assessments and the Mini Nutritional Assessment (MNA). Height, weight, body mass index (BMI) and triceps skin-fold thickness (TSFT) were selected as anthropometric indicators. TSFT was performed by vertically pulling out the skinfold 1 inch above the midpoint and applying the caliper jaws at the center of the standard midpoint. MNA is a scale designed to assess the nutritional status of individuals over 65 years of age. It is composed of a set of brief questions and simple measurements. MNA provides high sensitivity and specificity (Vellas et al., 1999). Moreover, the MNA is widely used in different populations for nutritional screening of patients with PD (Lin et al., 2020; G. Wang et al., 2010; Yang et al., 2020). The maximum score on the MNA test is 30 points from 18 items. A score less than 17 is indicative of undernutrition. A score of 24 points or more indicates a good nutritional status, and a score equal to or greater than 17, but equal to or less than 23.5 is indicative of a risk of undernutrition. Anthropometric and MNA were performed by two nutrition specialist nurses in our team.

The modified Hoehn and Yahr staging scale (H&Y) was used to evaluate disease severity (Goetz et al., 2004). It is generally considered that an H&Y stage of 1 to 2.5 indicates the early stage of PD and a score of 3 to 5 indicates an advanced stage.

The Clock-Drawing Test (CDT) was used to assess patients' cognitive function. CDT is a rapid and simple cognitive screening tool with a high correlation with the Mini-Mental State Examination (Agrell & Dehlin, 2012). Patients were asked to draw a clock, put in all the numbers, and set the time to 10 min past 11. There are many different scoring systems for the CDT, and we selected the widely used Sunderland scoring system (Sunderland et al., 1989). The Sunderland scoring system is a 10-point scale that assesses the integrity of the clockface, the layout of the numbers, and the position of the hands. A score of 6 or less is considered "abnormal," indicating significant cognitive impairment.

The 30 mL water swallow test was used to assess swallowing function (González-Fernández et al., 2013). Patients were instructed to drink 30 mL of room-temperature water while in a seated position. Based on the swallowing time and the presence of choking, the swallowing function was divided into 5 levels: level 1, can swallow water smoothly; level 2, can swallow more than twice, and does not appear to choke/cough when swallowing; level 3, swallowing can be done once, but is accompanied by choke/cough; level 4, requires two or more attempts to complete a swallow, and choke/cough occurs; level 5, frequent choking and coughs, and cannot swallow. A level of 1 or 2 with swallowing completed within 5 s was considered normal, while the remaining levels were considered abnormal, indicating a risk of choking and aspiration.

Comorbidities are very common in the elderly population and are closely related to nutritional status. We used Charlson Comorbidity Index (CCI) to assess comorbidities, which is the most commonly used (Charlson et al., 1987). In this study, age was considered as an independent variable, so the CCI score was not adjusted for age.

Ethics Committee

The study was approved by the ethics committee of the Second Affiliated Hospital of Zhejiang University (No. 2018-186). Written informed consent was obtained from all participants, according to the Declaration of Helsinki.

Statistical Analyses

The Kolmogorov-Smirnov test was used for normality testing. Continuous variables are reported as the mean ± standard deviation (*SD*) or median and interquartile range (IQR), and were analyzed by an independent t test or Mann–Whitney *U*-test, respectively. The one-way analysis of variance (ANOVA) was used when three or more independent groups were analyzed. Categorical data were represented as frequencies (percentages) and were analyzed using the chi-square test or Fisher's exact test.

A forward stepwise logistic regression model was performed to detect the interplay between nutritional status and clinical parameters. Abnormal nutrition (MNA ≤ 23.5) was used as a dependent variable. Sex, age, H&Y stage, disease duration, education level, CDT score, water swallow test score, and CCI score were considered covariables. The Goodness of Fit test was

Table 1. Demographic and Clinical Features of Different Nutritional Statuses.

Variables	Normal (A)	At risk (B)	Malnutrition (C)	Abnorml (B+C)	*p*-Value[a]	*p*-Value[b]
Number	559	202	24	226		
Age (years), mean (*SD*)	70.54 ± 4.36	73.43 ± 5.40	74.18 ± 7.22	73.50 ± 5.58	<.001	<.001
Female/male	259/300	87/115	9/15	96/130	.540	.366
Years of education (%)					.092	.238
≤6	294 (52.6)	90 (44.6)	17 (70.8)	107 (47.3)		
>6, ≤9	118 (21.1)	45 (22.3)	3 (12.5)	48 (21.2)		
>9, ≤12	88 (15.7)	47 (23.3)	2 (8.3)	49 (21.7)		
>12	59 (10.6)	20 (9.9)	2 (8.3)	22 (9.7)		
Disease duration (years), median (IQR)	6 (4–9)	8 (6–11)	9 (5–13)	8 (5.5–11)	<.001	<.001
Height (cm), mean (*SD*)	162.28 ± 8.02	159.92 ± 8.23	160.58 ± 7.65	159.99 ± 8.14	.042	.012
Weight (kg), mean (*SD*)	64.80 ± 10.02	53.85 ± 8.83	50.13 ± 9.67	53.46 ± 8.95	<.001	<.001
BMI (kg/m^2), mean (*SD*)	24.52 ± 2.90	21.01 ± 2.79	19.30 ± 2.54	20.83 ± 2.80	<.001	<.001
Swallow test, median (IQR)	1 (1–2)	1 (1–2)	2 (2–3)	2 (1–2)	<.001	<.001
CDT, median (IQR)	10 (8–10)	8 (4–10)	5 (2–8)	8 (4–8)	<.001	<.001
Skinfold thickness (mm), median (IQR)	15 (10–20)	10 (7–15.125)	8.5 (4.5–11.5)	10 (7–13.25)	<.001	<.001
H&Y, median (IQR)	2 (2–3)	2.5 (2–3)	3 (2.5–4)	2.5 (2–3)	<.001	<.001
Stage 1, NO. (%)	32 (5.7)	4 (2.0)	0 (0)	4 (1.8)		
Stage 1.5, NO. (%)	42 (7.5)	9 (4.5)	0 (0)	9 (4.0)		
Stage 2, NO. (%)	270 (48.3)	67 (33.2)	0 (0)	67 (29.6)		
Stage 2.5, NO. (%)	68 (12.2)	30 (14.9)	9 (37.5)	39 (17.3)		
Stage 3, NO. (%)	124 (22.2)	81 (40.1)	9 (37.5)	90 (39.8)		
Stage 4, NO. (%)	23 (4.1)	11 (5.4)	6 (25.0)	17 (7.5)		
CCI, mean (*SD*)	1.57 ± 0.96	2.32 ± 1.07	2.92 ± 1.06	2.38 ± 1.08	<.001	<.001

Note. SD = standard deviation; IQR = interquartile range; BMI = Body mass index; CDT = clock-drawing test; H&Y = Hoehn and Yahr; NO = number; CCI = Charlson Comorbidity Index.
The *p*-value[a] in group A versus group B versus group C; *p*-value[b] in group A versus group (B + C).

performed following the method of Hosmer and Lemeshow. Multicollinearity diagnostics were examined by computing the variance inflation factor (VIF). The cutoff threshold was a VIF value above 5. Multicollinearity was not a problem in this study, all VIF were <5.

Two-tailed *p*-values were calculated for all analyses. The alpha level of significance was set at 0.05. All analyses were performed using SPSS version 25 (IBM, Chicago, IL).

Results

Population Characteristics and Group Comparisons

Demographic and clinical characteristics of patients with different nutritional statuses are presented in Table 1. From all 785 patients enrolled, 559 (71.2%) patients presented with a normal nutritional status (MNA ≥ 24), 202 (25.7%) patients presented with at risk of undernutrition (17 ≤ MNA ≤ 23.5), and 24 (3.1%) patients presented with malnutrition (MNA < 17).

As shown in Table 1, we identified significant differences between the three groups based on age, disease duration, height, weight, BMI, water swallow test result, CDT score, triceps skinfold thickness, H&Y stage and CCI score. When merging the at risk of malnutrition group with the malnutrition group into a separate group (MNA ≤ 23.5, abnormal nutrition group), between-group differences were identified based on the same variables detailed above when compared to the normal nutrition group. There were no significant differences in the sex and education levels between groups.

Logistic Regression

With low BMI (≤18.5) as the dependent variable, we first performed univariate analysis and included statistically significant variables (age, CDT score < 6, abnormal water swallow test, CCI score) in the regression analysis. Based on clinical experience, we considered that H&Y stage, sex, education level, and disease duration might be related to nutritional status and therefore included them in the regression analysis, although they were not statistically significant.

Data from binary logistic regression analyses are shown in Table 2. H&Y stage ≥ 3, abnormal water swallow test, CDT score < 6, and higher CCI score are strongly associated with low BMI. Age, sex, disease

Table 2. Factors Associated With Low BMI in Elderly PD Patients and Their Adjusted Odds Ratios.

Variables		B	OR(95%CI)	*p*-Value
H&Y	1–2.5		1	
	3–5	0.776	2.151 (1.174–3.941)	.013
Water swallow test	normal		1	
	abnormal	1.517	4.559 (2.130–9.759)	<.001
CDT	6–10		1	
	1–5 (poor)	1.033	2.810 (1.543–5.148)	.001
CCI		0.483	1.621 (1.238–2.124)	<.001

Note. B = regression coefficient; CI = confidence interval; H&Y = Modified Hoehn and Yahr staging scale; CDT = clock-drawing test; CCI = Charlson Comorbidity Index.
The full model for logistic regression analysis included age, sex, years of education (≤6 years, 7–9 years, >9 years), disease duration (≤5 years, 5–10 years, >10 years), H&Y (1–2.5, 3–5), water swallowing test (normal: 1–2, abnormal: 3–5), CDT score (1–5, 6–10), and CCI score.

duration, and education level were not statistically significant.

Discussion

The relationship between PD and nutrition has garnered increasing attention. The majority of studies have concentrated on mitigating the incidence of PD, unveiling potential neuroprotective effects associated with certain dietary patterns, food components, and medicinal plants (Prakash et al., 2014; Yadav et al., 2017) . However, there remains a dearth of research regarding the nutritional status, related factors, and interventions for elderly patients already afflicted with PD.

Choosing the most suitable nutritional screening tool for PD remains controversial. MNA, malnutrition universal screening tool (MUST), Patient-Generated Subjective Global Assessment (PG-SGA), and BMI were used in previous studies (Barichella et al., 2013; Budrewicz et al., 2019; Sheard et al., 2013). We used MNA in this study because of its simplicity and efficacy in cross-sectional surveys.

The prevalence of malnutrition in patients with PD has also been controversial and based on prior studies using MNA, has ranged from 0% to 25.5% for malnourished patients and 19.66% to 55.2% for patients at risk of malnutrition(Fereshtehnejad et al., 2014; Lin et al., 2020; Tomic et al., 2017; Van Steijn et al., 2014; G. Wang et al., 2010; Yang et al., 2020). Some of these studies were conducted in East Asian populations, but their conclusions also varied widely (Lin et al., 2020; G. Wang et al., 2010; Yang et al., 2020). Such heterogeneous results may be due to the small sample sizes of previous studies, ranging from 35 to 556 patients. Small sample sizes may easily lead to statistical biases. The inclusion of all hospitalized patients, particularly those who were severely ill, in some studies resulted in a high prevalence rate. In addition, most of the studies did not strictly follow the scope of application of MNA and included some patients younger than 65 years, which may lead to deviation of the results. The difference in prevalence can also be explained by differences in race, living environment, and eating habits, among other factors. Our study included outpatient and ward patients with a wide range of disease severity. We evaluated patients over 65 years of age in accordance with the scope of application of MNA. Our results were similar to those of some other studies (Tomic et al., 2017), but slightly higher, both in terms of the prevalence of malnutrition and risk of malnutrition. This may be due to the older mean age of the patients enrolled and the inclusion of inpatients.

This study showed that nutritional status was correlated with H&Y stage. The data indicated that nutritional status was associated with disease severity. As PD progressed, energy consumption increased due to tremors, rigidity, and dyskinesia, leading to a negative energy balance and ultimately to malnutrition. The prevalence of PD patients at risk of malnutrition was 8.1%, 15.0% and 17.8% in H&Y stages 1, 1.5, and 2, respectively. Thus, nutritional problems can occur in the early stages of PD. A previous study also showed that people with early PD may experience a decline in BMI (Cheshire & Wszolek, 2005). Possible mechanisms for this phenomenon included the disturbance of smell and taste, reduced postprandial ghrelin response, psychiatric symptoms such as anxiety, depression, and apathy, or drug-induced gastrointestinal symptoms. Thus, nutritional screening for patients with PD should begin at an early stage.

In addition to H&Y stage and age, logistic regression analyses revealed that the water swallow test and CDT were also independently related to nutritional status. It was previously reported that the prevalence of dysphagia was 87.1% in the Chinese PD population (Ding et al., 2018). As a frequent non-motor symptom of PD, swallowing difficulties may disturb eating behaviors and limit food intake. Recent research findings revealed a distinct dysphagia pattern characterized by pharyngeal motor impairment, resulting in slow eating, choking, and an increased risk of aspiration pneumonia (P. Wang et al., 2024) . We hypothesize that this pattern of dysphagia may lead to reduced energy intake, subsequently contributing to nutritional problems among PD patients.

In this study, we observed that patients with significant cognitive impairment had a higher prevalence of nutritional problems. Several previous studies have noticed the association between cognitive decline and weight loss in PD patients (Lorefält et al., 2004). A retrospective study found patients with decreased BMI during initial 6 months of follow-up showed lower level of cognitive function than patients with stable BMI and had faster decline in cognitive function over the following 3 years. Decreased BMI during initial 6 months of follow-up in PD might be a useful indicator for future risk of dementia (Kim et al., 2012). This study corroborated the relation between cognition and nutritional status in PD.

However, the causal relationship between nutritional status and cognitive function remains unclear, and the pathophysiological association needs further investigation. Cognitive impairments in PD are characterized by impairments in attention, executive function, and visuospatial processing, which may be associated with eating behaviors (Emre et al., 2014). CDT serves as a highly sensitive measure of patients' visuospatial perception and executive function. Consequently, our conclusion suggests that impairments in visual spatial abilities and executive function may contribute to nutritional issues in PD patients. Moreover, a study has found that cognitive decline in PD is closely associated with gastrointestinal symptoms. MCI or dementia is more common among individuals with gastrointestinal symptoms, which may result from a disruption of the gut-brain axis (Jones et al., 2020). This may be another way to explain the relationship between cognitive function and nutritional status in PD patients, given the significant association between gastrointestinal symptoms and nutritional status.

In addition to PD, other chronic diseases are prevalent among the elderly. These comorbidities significantly affect the nutritional status of patients. Some possible reasons are: Diseases such as uncontrolled diabetes, malignant tumors, gastrointestinal diseases, and hyperthyroidism directly impact nutrient absorption and increase consumption. Comorbidities result in an increased range of medications, which can impact the appetite and gastrointestinal absorption. Prolonged pain and inconvenience caused by comorbidities may lead to depression and anxiety in older adults, subsequently affecting their appetite and eating behavior (Volkert et al., 2019). Comorbidities may restrict the mobility, making it challenging for them to engage in sufficient physical activity to stimulate appetite and promote digestion. Additionally, reduced social activities may also influence their eating preferences and habits. Limited economic conditions might prevent some older individuals from purchasing high-quality diverse foods, thereby limiting their overall nutrient intake (Dent et al., 2023). A previous study investigated the comorbidity of PD patients nationwide in China, and the CCI scores of the same age group were basically consistent with results of this study (X. Wang et al., 2017). We analyzed comorbidities that affect CCI scores. Most prevalent diseases were cerebrovascular disease without sequelae (33.8%), mild diabetes (30.1%), and chronic obstructive pulmonary disease (13.9%). Our analysis found no significant effects of individual diseases on patients' nutritional status; however, we did observe a positive correlation between the total CCI score and nutritional status. For individuals, we recommend actively managing comorbidities, controlling blood sugar levels, mitigating risk factors for cerebrovascular disease and smoking cessation.

The strength of this study is its large sample size. However, due to cross-sectional design, the temporal relationship between these factors and nutritional status cannot be determined. In addition, Assessment of social support and non-motor symptoms that may be related to nutritional status, such as anxiety, depression, and constipation, were not included in the study. Multi-center cohort studies with large sample size and long follow-up are needed in the future.

Conclusion

This multi-center cross-sectional study provides the prevalence of malnutrition and risk of malnutrition in elderly Chinese patients with PD. Logistic regression reveals disease severity, ability to swallow, cognitive function and comorbid conditions were associated with nutritional problems. These risk factors provide new considerations for nutritional interventions, aside from nutritional supplementation.

Acknowledgments

We would like to thank Department of Nutrition, the Second Affiliated Hospital of Zhejiang University for supporting the nutritional assessment and data collection.

Authors' Contributions

WL: Conceived the study question, and contributed to the study design, supervision of data collection. SW: Conceived the study question, data analysis and interpretation, and writing the manuscript. PL: Undertook data collection and data analysis, and contributed to data interpretation, and writing the manuscript. XT: Undertook data collection and data analysis. BW: Undertook data collection and data analysis.

ZO: Undertook data collection and data analysis.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by Health Commission of Zhejiang Province, China [2023566417].

ORCID iD

Sheng Wu https://orcid.org/0000-0001-7330-8872

References

Agrell, B., & Dehlin, O. (2012). The clock-drawing test. 1998. *Age and Ageing*, *41*(Suppl 3), iii41–iii45. https://doi.org/10.1093/ageing/afs149

Barichella, M., Cereda, E., Madio, C., Iorio, L., Pusani, C., Cancello, R., Caccialanza, R., Pezzoli, G., & Cassani, E. (2013). Nutritional risk and gastrointestinal dysautonomia symptoms in Parkinson's disease outpatients hospitalised on a scheduled basis. *The British Journal of Nutrition*, *110*(2), 347–353. https://doi.org/10.1017/S0007114512004941

Beyer, P. L., Palarino, M. Y., Michalek, D., Busenbark, K., & Koller, W. C. (1995). Weight change and body composition in patients with Parkinson's disease. *Journal of the American Dietetic Association*, *95*(9), 979–983. https://doi.org/10.1016/S0002-8223(95)00269-3

Budrewicz, S., Zmarzły, A., Rączka, D., Szczepańska, A., Koziorowska-Gawron, E., Słotwiński, K., & Koszewicz, M. (2019). Clinical and nutritional correlations in Parkinson's disease: Preliminary report. *Advances in Clinical and Experimental Medicine*, *28*(2), 193–198. https://doi.org/10.17219/acem/76375

Charlson, M. E., Pompei, P., Ales, K. L., & MacKenzie, C. R. (1987). A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *Journal of Chronic Diseases*, *40*(5), 373–383. https://doi.org/10.1016/0021-9681(87)90171-8

Cheshire, W. P., & Wszolek, Z. K. (2005). Body mass index is reduced early in Parkinson's disease. *Parkinsonism & Related Disorders*, *11*(1), 35–38. https://doi.org/10.1016/j.parkreldis.2004.07.001

Dent, E., Wright, O. R. L., Woo, J., & Hoogendijk, E. O. (2023). Malnutrition in older adults. *Lancet*, *401*(10380), 951–966. https://doi.org/10.1016/s0140-6736(22)02612-5

Ding, X., Gao, J., Xie, C., Xiong, B., Wu, S., Cen, Z., Lou, Y., Lou, D., Xie, F., & Luo, W. (2018). Prevalence and clinical correlation of dysphagia in Parkinson disease: A study on Chinese patients. *European Journal of Clinical Nutrition*, *72*(1), 82–86. https://doi.org/10.1038/ejcn.2017.100

Dorsey, E. R., Constantinescu, R., Thompson, J. P., Biglan, K. M., Holloway, R. G., Kieburtz, K., Marshall, F. J., Ravina, B. M., Schifitto, G., Siderowf, A., & Tanner, C. M. (2007). Projected number of people with Parkinson disease in the most populous nations, 2005 through 2030. *Neurology*, *68*(5), 384–386. https://doi.org/10.1212/01.wnl.0000247740.47667.03

Emre, M., Ford, P. J., Bilgiç, B., & Uç, E. Y. (2014). Cognitive impairment and dementia in Parkinson's disease: practical issues and management. *Movement Disorders*, *29*(5), 663–672. https://doi.org/10.1002/mds.25870

Fereshtehnejad, S. M., Ghazi, L., Sadeghi, M., Khaefpanah, D., Shahidi, G. A., Delbari, A., & Lökk, J. (2014). Journal of Parkinson's disease, *4*(3), 473–481. https://doi.org/10.3233/JPD-130323

Goetz, C. G., Poewe, W., Rascol, O., Sampaio, C., Stebbins, G. T., Counsell, C., Giladi, N., Holloway, R. G., Moore, C. G., Wenning, G. K., Yahr, M. D., & Seidl, L. (2004). Movement Disorder Society Task Force report on the Hoehn and Yahr staging scale: Status and recommendations. *Movement Disorders*, *19*(9), 1020–1028. https://doi.org/10.1002/mds.20213

González-Fernández, M., Huckabee, M. L., Doeltgen, S. H., Inamoto, Y., Kagaya, H., & Saitoh, E. (2013). Dysphagia rehabilitation: Similarities and differences in three areas of the World. *Current Physical Medicine and Rehabilitation Reports*, *1*(4), 296–306. https://doi.org/10.1007/s40141-013-0035-9

Jones, J. D., Rahmani, E., Garcia, E., & Jacobs, J. P. (2020). Gastrointestinal symptoms are predictive of trajectories of cognitive functioning in de novo Parkinson's disease. *Parkinsonism & Related Disorders*, *72*, 7–12. https://doi.org/10.1016/j.parkreldis.2020.01.009

Kim, H. J., Oh, E. S., Lee, J. H., Moon, J. S., Oh, J. E., Shin, J. W., Lee, K. J., Baek, I. C., Jeong, S. H., Song, H. J., Sohn, E. H., & Lee, A. Y. (2012). Relationship between changes of body mass index (BMI) and cognitive decline in Parkinson's disease (PD). *Archives of Gerontology and Geriatrics*, *55*(1), 70–72. https://doi.org/10.1016/j.archger.2011.06.022

Lin, T. K., Chang, Y. Y., Chen, N. C., Liou, C. W., Lan, M. Y., Chen, Y. F., & Tsai, C. L. (2020). Nutritional status associated with molecular biomarkers, physiological indices, and clinical severity in Parkinson's Disease patients. *International Journal of Environmental Research and Public Health*, *17*(16), 5727. https://doi.org/10.3390/ijerph17165727

Lorefält, B., Ganowiak, W., Pålhagen, S., Toss, G., Unosson, M., & Granérus, A. K. (2004). Factors of importance for weight loss in elderly patients with Parkinson's disease. *Acta Neurologica Scandinavica*, *110*(3), 180–187. https://doi.org/10.1111/j.1600-0404.2004.00307.x

Ma, K., Xiong, N., Shen, Y., Han, C., Liu, L., Zhang, G., Wang, L., Guo, S., Guo, X., Xia, Y., Wan, F., Huang, J., Lin, Z., & Wang, T. (2018). Weight loss and malnutrition in patients with Parkinson's disease: Current knowledge and future prospects. *Frontiers in Aging Neuroscience*, *10*, 1. https://doi.org/10.3389/fnagi.2018.00001

Postuma, R. B., Berg, D., Stern, M., Poewe, W., Olanow, C. W., Oertel, W., Obeso, J., Marek, K., Litvan, I., Lang, A. E., Halliday, G., Goetz, C. G., Gasser, T., Dubois, B., Chan, P., Bloem, B. R., Adler, C. H., & Deuschl, G. (2015). MDS clinical diagnostic criteria for Parkinson's disease. *Movement Disorders*, *30*(12), 1591–1601. https://doi.org/10.1002/mds.26424

Prakash, J., Chouhan, S., Yadav, S. K., Westfall, S., Rai, S. N., & Singh, S. P. (2014). Withania somnifera alleviates parkinsonian phenotypes by inhibiting apoptotic pathways in dopaminergic neurons. *Neurochemical Research*, *39*(12), 2527–2536. https://doi.org/10.1007/s11064-014-1443-7

Rai, S. N., & Singh, P. (2020). Advancement in the modelling and therapeutics of Parkinson's disease. *Journal of Chemical Neuroanatomy*, *104*, 101752. https://doi.org/10.1016/j.jchemneu.2020.101752

Sheard, J. M., Ash, S., Mellick, G. D., Silburn, P. A., & Kerr, G. K. (2013). Malnutrition in a sample of community-dwelling people with Parkinson's disease. *PLoS One*, *8*(1), e53290. https://doi.org/10.1371/journal.pone.0053290

Sheard, J. M., Ash, S., Silburn, P. A., & Kerr, G. K. (2011). Prevalence of malnutrition in Parkinson's disease: A systematic review. *Nutrition Reviews*, *69*(9), 520–532. https://doi.org/10.1111/j.1753-4887.2011.00413.x

Sunderland, T., Hill, J. L., Mellow, A. M., Lawlor, B. A., Gundersheimer, J., Newhouse, P. A., & Grafman, J. H. (1989). Clock drawing in Alzheimer's disease. A novel measure of dementia severity. *Journal of the American Geriatrics Society*, *37*(8), 725–729. https://doi.org/10.1111/j.1532-5415.1989.tb02233.x

Tomic, S., Pekic, V., Popijac, Z., Pucic, T., Petek, M., Kuric, T. G., Misevic, S., & Kramaric, R. P. (2017). What increases the risk of malnutrition in Parkinson's disease? *Journal of Neurological Sciences*, *375*, 235–238. https://doi.org/10.1016/j.jns.2017.01.070

van der Marck, M. A., Dicke, H. C., Uc, E. Y., Kentin, Z. H., Borm, G. F., Bloem, B. R., Overeem, S., & Munneke, M. (2012). Body mass index in Parkinson's disease: A meta-analysis. *Parkinsonism & Related Disorders*, *18*(3), 263–267. https://doi.org/10.1016/j.parkreldis.2011.10.016

Van Steijn, J., Van Harten, B., Flapper, E., Droogsma, E., Van Walderveen, P., Blaauw, M., & Van Asselt, D. (2014). The nutritional status of Dutch elderly patients with Parkinson's disease. *Journal of Nutrition Health & Aging*, *18*(6), 601–607. https://doi.org/10.1007/s12603-014-0444-1

Vellas, B., Guigoz, Y., Garry, P. J., Nourhashemi, F., Bennahum, D., Lauque, S., & Albarede, J. L. (1999). The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition (Burbank, Los Angeles County, Calif*, *15*(2), 116–122. https://doi.org/10.1016/s0899-9007(98)00171-3

Volkert, D., Kiesswetter, E., Cederholm, T., Donini, L. M., Eglseer, D., Norman, K., Schneider, S. M., Ströbele-Benschop, N., Torbahn, G., Wirth, R., & Visser, M. (2019). Development of a model on determinants of malnutrition in aged persons: A MaNuEL project. *Gerontology and Geriatric Medicine*, *5*, 2333721419858438. https://doi.org/10.1177/2333721419858438

Wang, G., Wan, Y., Cheng, Q., Xiao, Q., Wang, Y., Zhang, J., Ma, J. F., Wang, X. J., Zhou, H. Y., & Chen, S. D. (2010). Malnutrition and associated factors in Chinese patients with Parkinson's disease: Results from a pilot investigation. *Parkinsonism & Related Disorders*, *16*(2), 119–123. https://doi.org/10.1016/j.parkreldis.2009.08.009

Wang, P., Chen, X., Chen, M., Gao, L., Xiong, B., Ji, C., Shen, Q., Shen, Y., Wu, S., Pan, Y., Li, J., Wang, B., & Luo, W. (2024). Dysphagia pattern in early to moderate Parkinson's disease caused by abnormal pharyngeal kinematic function. *Dysphagia*. Advance online publication. https://doi.org/10.1007/s00455-024-10672-8

Wang, X., Zeng, F., Jin, W. S., Zhu, C., Wang, Q. H., Bu, X. L., Luo, H. B., Zou, H. Q., Pu, J., Zhou, Z. H., Cui, X. P., Wang, Q. S., Shi, X. Q., Han, W., Wu, Q., Chen, H. S., Lin, H., Zhang, L. L., Zhang, M., . . . Wang, Y. J. (2017). Comorbidity burden of patients with Parkinson's disease and Parkinsonism between 2003 and 2012: A multicentre, nationwide, retrospective study in China. *Scientific Reports*, *7*(1), 1671. https://doi.org/10.1038/s41598-017-01795-0

Yadav, S. K., Rai, S. N., & Singh, S. P. (2017). Mucuna pruriens reduces inducible nitric oxide synthase expression in Parkinsonian mice model. *Journal of Chemical Neuroanatomy*, *80*, 1–10. https://doi.org/10.1016/j.jchemneu.2016.11.009

Yang, T., Zhan, Z., Zhang, L., Zhu, J., Liu, Y., Zhang, L., Ge, J., Zhao, Y., Zhang, L., & Dong, J. (2020). Prevalence and risk factors for malnutrition in patients with Parkinson's disease. *Frontiers in Neurology*, *11*, 533731. https://doi.org/10.3389/fneur.2020.533731

Zhang, Z. X., Roman, G. C., Hong, Z., Wu, C. B., Qu, Q. M., Huang, J. B., Zhou, B., Geng, Z. P., Wu, J. X., Wen, H. B., Zhao, H., & Zahner, G. E. (2005). Parkinson's disease in China: Prevalence in Beijing, Xian, and Shanghai. *Lancet*, *365*(9459), 595–597. https://doi.org/10.1016/s0140-6736(05)17909-4