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Review

Predictors of recovery from dysphagia after stroke: A systematic review and meta-analysis

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A B S T R A C T

Objective: This systematic review aimed to identify the predictors of recovery from dysphagia after stroke in the last ten years, thereby providing an evidence-based basis for nurses to identify high-risk patients and develop individualized rehabilitation plans to improve patient prognosis.

Methods: Databases including the China National Knowledge Infrastructure (CNKI), China Biology Medicine disc (CBMdisc), China Science and Technology Journal (VIP), WanFang, PubMed, Embase, CINAHL, Web of Science, the Cochrane Library, and Scopus were retrieved to search for literature on the predictors of recovery from dysphagia after stroke. The retrieval period was from January 2013 to December 2023. The quality of studies was assessed using the Newcastle-Ottawa Scale (NOS) and the Prediction model Risk of Bias Assessment Tool (PROBAST). Meta-analysis was performed using Revman5.3 and Stata15.1 software. The review protocol has been registered with PROSPERO (CRD42024605570).

Results: A total of 1,216 results were obtained, including 599 in English and 617 in Chinese. A total of 34 studies were included, involving 156,309 patients with post-stroke dysphagia, and the rate of dysphagia recovery increased from 13.53% at 1 week to 95% at 6 months after stroke. Meta-analysis results showed that older age [OR = 1.06, 95%CI (1.04, 1.08), P < 0.001], lower BMI [OR = 1.28, 95%CI (1.17, 1.40), P < 0.001], bilateral stroke [OR = 3.10, 95%CI (2.04, 4.72), P < 0.001], higher National Institutes of Health Stroke Scale (NIHSS) score [OR = 1.19, 95%CI (1.01, 1.39), P = 0.030], tracheal intubation [OR = 5.08, 95%CI (1.57, 16.39), P = 0.007] and aspiration [OR = 4.70, 95%CI (3.06, 7.20), P < 0.001] were unfavorable factors for the recovery of swallowing function in patients with post-stroke dysphagia.

Conclusions: The lack of standardized criteria for rehabilitation assessment of post-stroke dysphagia has resulted in reported recovery rates of swallowing function exhibiting wide variability. Nurses should take targeted preventive measures for patients aged ≥70 years, low BMI, bilateral stroke, high NIHSS score, tracheal intubation, and aspiration to promote the recovery of swallowing function in patients with post-stroke dysphagia.

What is known?

- Post-stroke dysphagia (PSD) is a common complication in stroke patients, significantly impacting their quality of life and prognosis.
- Accurate prediction of PSD recovery is crucial for developing personalized rehabilitation plans.
- Previous studies have identified several potential predictors of PSD recovery.

What is new?

- This review provides a comprehensive summary of predictors of PSD recovery over the past decade, including a large sample size of 156,309 patients from 34 studies.

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- This finding underscores the dynamic nature of PSD recovery and the potential for substantial improvement in swallowing function over an extended period.
- The study identifies specific unfavorable factors for PSD recovery, including older age, lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration.

1. Introduction

According to the 2019 Global Burden of Disease study (GBD), stroke is the second leading cause of death worldwide and the third leading cause of death associated with disability, with an estimated 12.2 million new strokes occurring globally each year, affecting an estimated 101 million people [1,2]. Stroke can lead to a variety of functional disorders, seriously affecting the quality of life of patients, among which post-stroke dysphagia (PSD) is one of the most common complications [3,4]. The incidence of PSD varies depending on the assessment method, assessment tool, and assessment time. Studies showed that 29%–81% of stroke patients suffered dysphagia [5–7]. An epidemiological study examining swallowing dysfunction in a specific Chinese population found that the incidence of swallowing dysfunction was 46.3% in the acute stage of stroke, and this rate increased to 59.0% in the recovery stage of stroke [8]. Dysphagia not only leads to aspiration, lung infection, dehydration, electrolyte disturbance, malnutrition, and other problems but also is an independent risk factor for death in stroke patients [9–13]. Therefore, timely identification of dysphagia and accurate prediction of the possibility of recovery of patients' swallowing function is crucial for determining patients' feeding methods, developing personalized rehabilitation nursing plans, and optimizing the allocation of medical resources.

At present, systematic reviews of predictors of dysphagia recovery after stroke are rare. Wilmoskoetter et al. [14] conducted a systematic review of the predictors of removal of Gastrostomy tubes in patients undergoing Percutaneous Endoscopic Gastrostomy (PEG) for PSD; however, they did not include patients with post-stroke dysphagia who underwent nasogastric tube (NGT) or other means of compensating nutrition (changing food texture, etc.). Thus, D'Netto et al. [15] conducted a systematic review of predictors of dysphagia recovery after stroke, which included both the changes in the severity of dysphagia as assessed by the clinical swallowing scale and improvements in oral and/or enteral feeding patterns at the end of follow-up; however, D'Netto et al. [15] only performed a scoping review of predictors of dysphagia recovery after stroke, did not perform a meta-analysis of predictors, and most of the included studies were retrospective and 86% were ischemic stroke patients. Therefore, the results are limited to generalizing to the broader stroke population. In 2024, Mao et al. [16] conducted a systematic review of factors affecting poor recovery of swallowing disorders in stroke patients, and the meta-analysis results showed that older age, higher National Institutes of Health Stroke Scale (NIHSS) score, bilateral stroke, lower BMI, higher the modified Rankin Scale (mRS) score, lower Barthel Index (BI), lower Functional Indepen-dence Measure (FIM) score, higher low-density lipoprotein (LDL) level, cognitive disorder, aspiration, intubation duration were the risk factors for poor swallowing function recovery in stroke patients. However, most of the studies included in this systematic review were conducted 10–20 years ago, including the results of univariate analyses of the included studies, and multiple influencing factors were reported in only 1–2 studies, nor were evaluation criteria for the recovery of post-stroke dysphagia and the recovery rate described in detail.

This review aimed to systematically evaluate and synthesize the research published over the past decade on factors that predict recovery from dysphagia after stroke. The ultimate purposes of this review were to analyze the various potential predictors' associations with swallowing recovery and to evaluate the application prospects of these factors in clinical practice to provide clinicians with a comprehensive guide better to understand the recovery process for post-stroke swallowing disorder and help healthcare providers develop more personalized rehabilitation care plans for patients. This study was registered with PROSPERO (CRD42024605570).

2. Methods

2.1. Search strategy

Searching databases included the China National Knowledge Infrastructure (CNKI), China Biology Medicine disc (CBMdisc), China Science and Technology Journal (VIP), WanFang, PubMed, Embase, CINAHL, Web of Science, the Cochrane Library, and Scopus. Search terms combine the Mesh and free words. The search period was from January 2013 to December 2023. This approach helps to prevent potential obsolescence of information and degradation of data quality in long-term datasets, ensuring the timeliness and reliability of the information retrieved. In addition, retrospective searches were conducted through references included in the studies. Search terms included "stroke," "ischemic stroke," "hemorrhagic stroke," "embolic stroke," "thrombotic stroke," "brain stem infarctions," "cerebrovascular accident," "deglutition disorders," "dysphagia," "oropharyngeal dysphagia," "esophageal dysphagia," "prognosis," "treatment outcome," "recovery of function," "rehabilitation," "risk factors," "predictor," "associated factor," "influence factor," "predictive factor," "correlative factor," "correlation factor," and Boolean operators such as "AND" and "OR" were used to construct the search strategy. The information on the search strategy is in Appendix A.

2.2. Inclusion and exclusion criteria

Inclusion criteria: patients were $\geq$ 18 years old with dysphagia after stroke; the study was to analyze the predictive factors that may affect the recovery of dysphagia after stroke or to construct and verify the prediction model of the recovery of dysphagia after stroke; the study design was the original study of model construction or validation, including cohort study and case-control study. Exclusion criteria: duplicate publications, full text not available, published not in Chinese or English, the quality assessment score $\leq$ 3 points evaluated by the Newcastle-Ottawa Scale (NOS) [17], and the high risk of evaluation by the prediction model risk of bias assessment tool (PROBAST) [18,19].

2.3. Study selection process and data extraction

NoteExpress software was used to summarize and de-duplicate the retrieved articles. The two researchers (X. Jin, D. Li) independently read the title and abstract, according to the scheduling standard for preliminary screening, and then checked the abstract one by one. If the two researchers do not agree, the third researcher is asked to help judge, and the lack of data should contact the author to supplement. After the preliminary screening, the full text was read, and the included article was rescreened. The data extraction was completed using Excel Office, and the extracted data included patient characteristics, study design, time and method of swallowing function assessment, predictors (OR and 95%*CI*), and recovery of swallowing function.

2.4. Quality assessment

Two researchers (X. Jin, D. Li) independently evaluated the quality of the included articles, and if there was any disagreement, it was resolved through discussion or by asking a third researcher (H.Y. Tong) to assist in the evaluation. The NOS [17] was used to evaluate cohort studies [18] and case-control studies [19]. This scale included three dimensions of population selection, intergroup comparability, and exposure/outcome measurement, with 8 items. Quality evaluation scores ranging from 0 to 3 were classified as low-quality, 4 to 6 as medium-quality, and 7 to 9 as high-quality. The PROBAST [20,21] was used to evaluate the risk of bias and applicability. The bias risk was assessed from 4 domains: research subjects, predictor, outcome, and statistical analysis. Each domain covered 2–9 signature questions and 20 signature questions. The results for each area were assessed as low risk, high risk, or unclear. The applicability evaluation included subjects, predictors, and outcomes. The assessment methods were similar to the risk of bias, but there were no signature issues in each field.

2.5. Data analysis

All statistical calculations were performed using Stata version 15.1 and Review Manager5.3, with *OR* and 95%*CI* as the effect indicators and a test level of $\alpha = 0.05$. Cochran's *Q* test and Higgins I^2 statistics were used to determine the heterogeneity among the included studies, and I^2 reflected the proportion of heterogeneity in the total variance of the effect size. If $I^2 < 50$ % and $P > 0.1$ in the *Q* test, it indicated that the heterogeneity among studies was small, and the data were combined using a fixed-effects model; if $I^2 \geq 50\%$ or $P \leq 0.1$ in the *Q* test, it indicated that the heterogeneity among studies was large, the data were combined using a random effects model. A sensitivity analysis was also conducted by comparing the results of the fixed-effects model with those of the random-effects model. Potential publication bias was examined using Begg's tests. $P < 0.05$ (two-sided) was considered statistically significant.

3. Results

As shown in Fig. 1 and 1,216 results were obtained, including 599 in English and 617 in Chinese. After excluding the deduplications, 674 studies were obtained, and 85 were identified for full-text assessment. Finally, 34 studies fit our criteria and were included [22–55].

3.1. Study setting and patient characteristics

Appendix B provides information about the study setting and patient characteristics. The publication period was 2014–2023, and the types of studies included case-control studies ($n = 9$), retrospective cohort ($n = 16$), prospective cohort ($n = 6$), and prognostic model development/validation ($n = 3$). The sample size of the included studies was from 32 to 151,302, with a total of 156,309 participants, including 75,361 males (48.24%) and 80,862 females (51.76%) (one study [50] did not report the gender of the participants). The mean age was from 59.5 to 83.8 years old. Among them, except three studies [22,23,46] did not describe the stroke type, 13 studies [26–31,33,37,40,42,50,51,53] included the ischemic stroke (IS) only, and all others included both intracerebral hemorrhage (ICH) stroke and IS. In total, 72,707 (46.71%) patients were IS and ICH 57,385 (36.87%), Subarachnoid Hemorrhage (SAH) 25,528(16.40%), others 41(0.02%), respectively.

3.2. Quality evaluation of the included studies

Appendix C shows the quality of the included studies. The NOS was used to evaluate the quality of cohort and case-control studies, with scores ranging from 6 to 9. Among them, five studies [22,35,39,45,46] were of moderate quality, and 26 studies [23–28,31–34,36–38,40,41,43,44,47–55] were of high quality. The PROBAST was used to evaluate the bias risk and applicability of the included studies. Among them, two studies [29,42] were at high risk of overall bias, one study [30] was at low risk of overall bias, and three studies [29,30,42] were all at low risk of overall applicability.

3.3. Evaluation criteria and measurement tools for dysphagia recovery

A total of 22 included studies [23,25,27–29,32–34,36–40, 42–44,46,48,49,51,52,54] used instrumental assessments, including Videofluoroscopic Swallowing Study (VFSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES). The evaluation time of the recovery of swallowing function ranged from 1 week to 6 months after the stroke, and the recovery of swallowing function was mainly manifested by the change in eating patterns or the change in the severity of dysphagia. In 8 studies [25,27,34,47–49,53,54], swallowing function recovery was defined as removing the feeding tube and resuming the oral diet. In 8 studies [23,28,29,32,37,39,51,52], VFSS and FEES were used to determine whether the swallowing function was restored to the pre-stroke oral diet state. In addition, the water swallowing test [22,24,26,36] and the Functional Oral Intake Scale (FOIS) [30,31,33,40,42] were also used to determine whether swallowing function was restored.

The recovery rate of swallowing function in the included studies showed significant differences due to the different assessment tools and criteria used. Moreover, the recovery rate increased from 13.53% at one week to 95% at 6 months after stroke. Wang et al. [42] report 13.53% of patients with PSD recovered swallowing function on the 7th day after stroke (FOIS score reached 7); However, in a prospective study by Hota et al. [43], most of the patients with PSD could resume oral eating at 6 months after stroke, and only 5% of the patients needed tube feeding.

3.4. Clinical predictors of dysphagia recovery

Studies were included in the meta-analysis if they were analyzed multifactorial and provided *ORs* and 95% *CIs* for predictors or provided raw data that could be transformed, and if there were ≥3 studies mentioning this predictive factor. The results were as follows:

3.4.1. Results of meta-analysis

The results of the meta-analysis showed that older age, lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration were unfavorable factors for the recovery of swallowing function in patients with post-stroke dysphagia ($P < 0.05$), as shown in Table 1 and Fig. 2.

(1) Older age. Six studies [23,25,42,49,52,55] involved the effect of age on the recovery of swallowing function in PSD, and the heterogeneity among the studies was small ($I^2 = 25\%$, $P = 0.25$), so the fixed effect model was used for the analysis. Meta-analysis results showed that older age was an unfavorable factor for the recovery of swallowing function in PSD [$OR = 1.06$, 95%*CI* (1.04, 1.08), $P < 0.00001$], as shown in Appendix D.

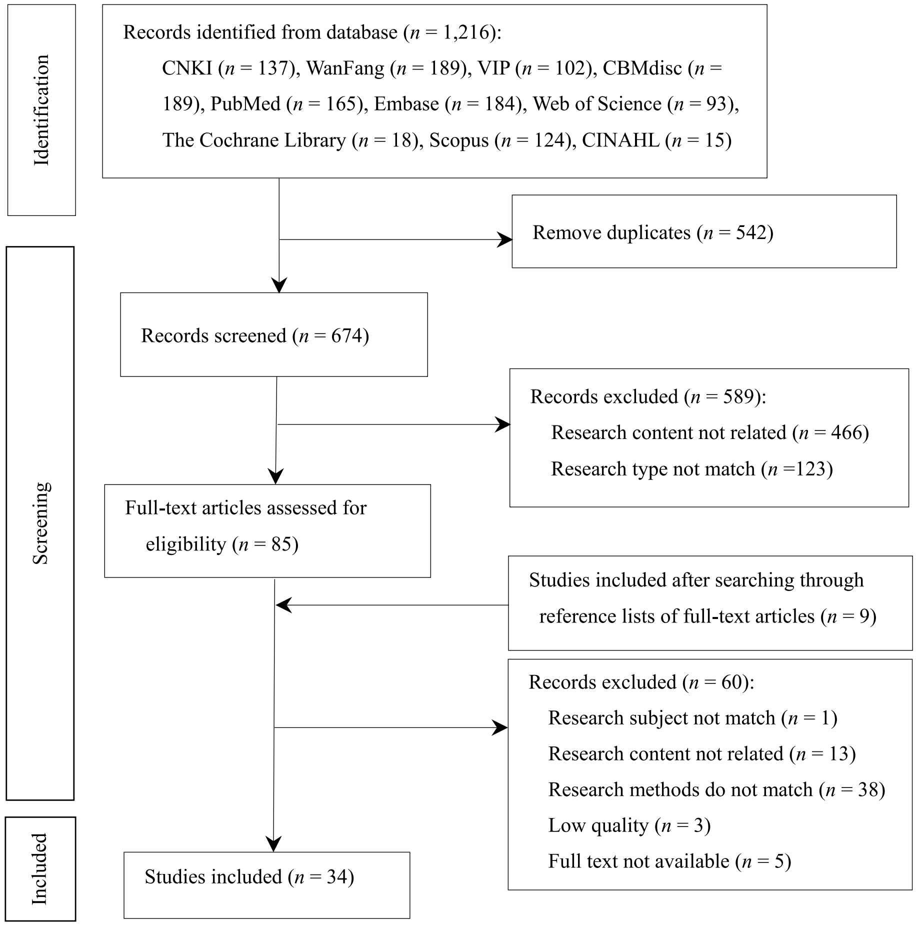

Fig. 1. Flow chart of study selection.

(2) Lower BMI. Three studies [25,34,42] involved the effect of BMI on the recovery of swallowing function in PSD, and the heterogeneity among the studies was small ($I^2 = 0\%$, $P = 0.83$), so the fixed effect model was used for the analysis. Meta-analysis results showed that lower BMI was an unfavorable factor for the recovery of swallowing function in PSD [$OR = 1.28$, 95%CI (1.17, 1.40), $P < 0.00001$], as shown in Appendix D.

(3) Bilateral stroke. Three studies [24,42,51] involved the effect of bilateral stroke on the recovery of swallowing function in PSD, and the heterogeneity among the studies was small ($I^2 = 15\%$, $P = 0.31$), so the fixed effect model was used for the analysis. Meta-analysis results showed that bilateral stroke was an unfavorable factor for the recovery of swallowing function in PSD [$OR = 3.10$, 95%CI (2.04, 4.72), $P < 0.00001$], as shown in Appendix D.

(4) Higher NIHSS score. Four studies [23,26,42,52] involved the effect of NIHSS score on the recovery of swallowing function in PSD, and the heterogeneity among the studies was large ($I^2 = 82\%$, $P = 0.001$), so the random effect model was used for analysis. Meta-analysis results showed that a higher NIHSS score was an unfavorable factor for the recovery of swallowing function in PSD [$OR = 1.19$, 95%CI (1.01, 1.39), $P = 0.03$], as shown in Appendix D.

(5) Tracheal intubation. Three studies [23,51,52] involved the effect of tracheal intubation on the recovery of swallowing function in PSD, and the heterogeneity among the studies was large ($I^2 = 77\%$, $P = 0.01$), so the random effect model was used for the analysis. Meta-analysis results showed that

Table 1
Meta-analysis results of predictors of swallowing function recovery in PSD patients.

Predictors	Number of studies	Heterogeneity test			Effect model	Meta-analysis		
		I^2 (%)	χ^2	P		OR (95%CI)	Z	P
Older age	6 [23,25,42,49,52,55]	25	6.64	0.25	Fixed	1.06 (1.04, 1.08)	5.64	<0.001
Lower BMI	3 [25,34,42]	0	0.38	0.83	Fixed	1.28 (1.17, 1.40)	5.35	<0.001
Bilateral stroke	3 [24,42,51]	15	2.36	0.31	Fixed	3.10 (2.04, 4.72)	5.29	<0.001
Higher NIHSS score	4 [23,26,42,52]	82	16.29	<0.01	Random	1.19 (1.01, 1.39)	2.13	0.030
Tracheal intubation	3 [23,51,52]	77	8.86	0.01	Random	5.08 (1.57, 16.39)	2.72	0.007
Aspiration	3 [23,48,51]	2	2.05	0.36	Fixation	4.70 (3.06, 7.20)	7.10	<0.001

Note: PSD = post-stroke dysphagia. NIHSS = National Institutes of Health Stroke Scale.

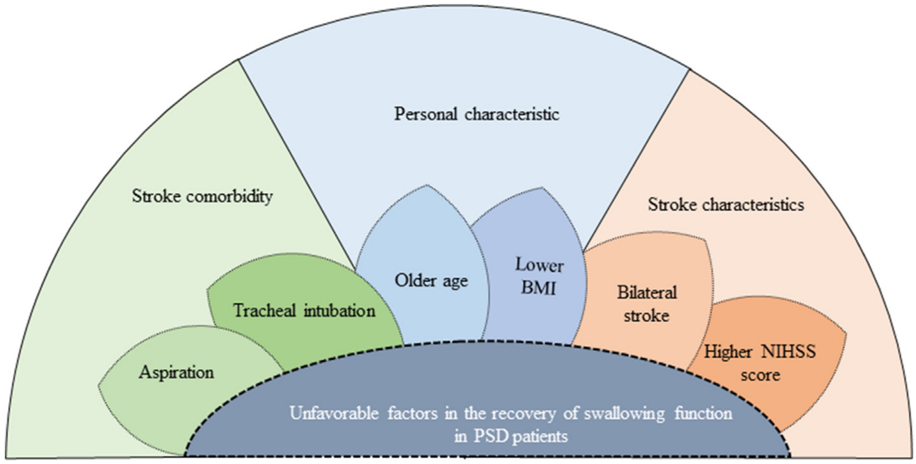

Fig. 2. Meta-analysis results of predictors of swallowing function recovery in PSD patients. PSD = post-stroke dysphagia. NIHSS = National Institutes of Health Stroke Scale.

tracheal intubation was an unfavorable factor for the recovery of swallowing function in PSD [*OR* = 5.08, 95%*CI* (1.57, 16.39), $P = 0.007$], as shown in Appendix D.

(6) Aspiration. Three studies [23,48,51] involved the effect of aspiration on the recovery of PSD swallowing function, and the heterogeneity among the studies was small ($I^2 = 2\%$, $P = 0.36$), so the fixed effect model was used for the analysis. Meta-analysis results showed that aspiration was an unfavorable factor for the recovery of swallowing function in PSD [*OR* = 4.70, 95%*CI* (3.06, 7.20), $P < 0.0001$], as shown in Appendix D.

3.4.2. Sensitivity analysis

A sensitivity analysis was also conducted by comparing the results of the fixed-effects model with those of the random-effects model. The results of the two-effects models for older age, lower BMI, bilateral stroke, higher NIHSS score, and aspiration were close, suggesting good reliability of the combined results; there were some differences between the results of the fixed-effects model and the random-effects model of tracheal intubation, suggesting poor reliability of the combined results of this factor, as shown in Appendix E.

3.4.3. Publication bias

Begg's test was performed on the studies with six predictors, and the results showed that there was a possible publication bias in the studies with age as a predictor ($P < 0.05$), and there was no significant publication bias in the studies with lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration as a predictor ($P > 0.05$), as shown in Appendix F.

4. Discussion

4.1. The evaluation criteria for the recovery of post-stroke dysphagia and the recovery rate are diverse

Our review indicated that the rate of dysphagia recovery increased with the duration of post-stroke follow-up, from 13.53% at one week to 95% at six months after stroke. The occurrence of PSD is mainly caused by damage to the swallowing cortex center, the bulbar swallowing center, the descending cortical fibers, and the extrapyramidal system and is closely related to the disrupting cerebral blood circulation, apoptosis, and necrosis of brain neurons [56]. A large number of brain cells will die in the hyperacute phase within one week of stroke, followed by apoptosis, further activation of local immune response in microglia and astrocytes, and migration of reactive immune cells to the stroke area and secretion of pro-inflammatory factors within the acute period of two weeks [57]. A series of changes, such as nerve repair and regeneration, neural network reconstruction, and brain function reorganization, will occur in the brain along with different degrees of brain tissue injury after stroke, which help the brain repair and recovery to a certain extent. The nervous system's ability to adjust structurally and functionally in response to injury is known as "neuroplasticity" [58]. Neuroplasticity is essential for the recovery of function in stroke patients. Neuroplasticity begins within hours of the onset of stroke symptoms, reaches maximum activity during the subacute phase, and may persist long after stroke [59]. Under different conditions, various therapeutic rehabilitation measures, such as pharmacological treatment, electro-acupuncture, cellular therapy, non-invasive neuromodulation techniques, etc., can enhance, promote and consolidate neuroplasticity, which contributes to swallowing function recovery. The rate of dysphagia recovery showed differences in different studies, which may be related to the inconsistent criteria used to evaluate swallowing function recovery. In the included studies, the dysphagia recovery was mainly reflected in two aspects: improvement of eating patterns and reduction of dysphagia degree. The differences in evaluation criteria can contribute to differences in recovery rates between studies and constrain the comparisons of swallowing recovery between studies.

4.2. Older age, lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration are unfavorable factors for swallowing function recovery in PSD patients

In this study, sensitivity analysis and publication bias assessments were conducted to determine the reliability of our results. The sensitivity analysis, comparing the outcomes from the fixed-effects and random-effects models, showed that for most predictive factors, the results were very close between the two models. Moreover, no significant publication bias was observed for these factors ($P > 0.05$), indicating that these results are fairly reliable and robust. The meta-analysis indicated that older age, lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration are unfavorable factors for the recovery of swallowing function in patients with post-stroke dysphagia ($P < 0.05$).

The results showed that older age was an unfavorable factor for the recovery of swallowing function in PSD. Lu et al. [22] and Zhan et al. [24] found that an age ≥70 years was associated with poor prognosis of swallowing function. With the increase of age, a series of physiological changes occur in the natural aging process, such as decreased muscle content and function, reduced salivation, dental damage, reduced oropharyngeal sensitivity, decreased olfactory and taste function, and decreased nerve compensatory ability, etc. [60]. These physiological changes increase the risk of dysphagia in older adults. At the same time, elderly patients with age advancement tend to have more severe symptoms of neurological impairment due to declining body functions and reduced tolerance of the disease [61]. Therefore, age is an important predictor of dysphagia recovery, and elderly patients with dysphagia are also the key groups for the evaluation and intervention of dysphagia.

Meanwhile, lower BMI was a significant negative predictor of resumption of oral intake in patients with post-stroke dysphagia [$OR = 1.28$, 95%CI (1.17, 1.40), $P < 0.001$]. Inooka et al's study [45] showed that a low BMI (< 18.5) was a predictor of poor recovery of total oral intake within 30 days of admission. To analyze the possible reasons, patients with lower BMI on admission may have more severe dysphagia because lower BMI reflects the patient's sarcopenia and organismal fragility, and recent studies have reported that sarcopenia reduces the pharyngeal muscle strength and tongue pressure, which can lead to dysphagia [62]. In addition, malnutrition is strongly associated with dysphagia, and patients with low BMI are more likely to be malnourished during the disease, which in turn can exacerbate dysphagia [63]. Therefore, to promote the early resumption of oral feeding, progressive nutritional support and swallowing rehabilitation training should be given to patients with low BMI on admission.

In terms of the lesion site of stroke, the results showed that bilateral stroke was an unfavorable factor for the recovery of swallowing function in PSD, and the recovery of swallowing function in PSD patients with bilateral stroke was 32% of that in patients with unilateral stroke. Oh et al. [52] proposed that multiple stroke locations are associated with an increased risk of poor swallowing outcomes. Swallowing function is a complex physiological activity in which the cortex, subcortical nucleus, descending cortical conduction fibers, brain stem, cerebellum, and other parts are involved in swallowing action, and any injury can lead to dysphagia. The swallowing cortex centers are mainly concentrated in the primary sensorimotor cortex/premotor area, anterior cingulate gyrus, insula, and parieto-occipital area, which can initiate swallowing and control the oral and pharyngeal stages and co-regulate the swallowing pattern of the bulbar swallowing center with the subcortical associated fibers [64]. The swallowing central pattern generator of the medulla bulbosa is responsible for receiving regulatory signals from the bilateral cerebral cortex and subcortex and sensory signals from cranial nerves (such as glossopharyngeal nerve, trigeminal nerve, facial nerve, etc.), and after processing signals from the hypoglossal nerve, glossopharyngeal nerve, vagus nerve, etc., to regulate the sequential movement of swallowing related muscles [65]. Studies have shown that the swallowing cortex of both hemispheres is asymmetrical; that is, there is a swallowing "dominant" hemisphere. The patient may have short-term swallowing disorders when the injury site is located in the dominant hemisphere. As time passes, the healthy hemisphere can compensate for the swallowing function, and the patient's swallowing function may be restored. When both hemispheres are damaged, patients' swallowing function can not be compensated, more serious swallowing disorders can occur, and even aspiration [66]. Therefore, swallowing treatment and rehabilitation should be strengthened for patients with bilateral cerebral hemispheres after stroke to promote the early recovery of swallowing function.

Regarding stroke severity, the results showed that a higher NIHSS score was an unfavorable factor for the recovery of swallowing function in PSD. Kumar et al. [51] found that NIHSS score ≥12 was a risk factor for poor prognosis of swallowing function after stroke. NIHSS is a tool for quantitatively evaluating the severity of neurological deficits in stroke patients, with higher NIHSS scores suggesting more severe deficits in cerebral neurological function. A meta-analysis by Mao et al. [16] also yielded consistent results that a higher NIHSS score (≥ 8) was a risk factor for poor prognosis of swallowing function after stroke. Moreover, Lin et al. [40] found that early dysphagia improvement after stroke was negatively correlated with NIHSS scores of facial palsy (NIHSS item 4) and speech/aphasia (NIHSS item 9). Therefore, patients with higher NIHSS scores on admission, especially those with higher scores in facial palsy and speech/aphasia, should be given timely swallowing rehabilitation to promote early improvement of swallowing function.

In terms of stroke comorbidities, the results showed that tracheal intubation [$OR = 5.08$, 95%CI (1.57, 16.39), $P = 0.007$] and aspiration [$OR = 4.70$, 95%CI (3.06, 7.20), $P < 0.00001$] were risk factors for poor swallowing function recovery in PSD. The recovery of swallowing function of PSD patients with tracheal intubation was 19.7% of that of PSD patients without tracheal intubation, and the recovery of swallowing function of PSD patients with aspiration was 21.3% of that of PSD patients without aspiration. When stroke patients appear to disturbance consciousness due to severe brain injury or due to impaired airway protective reflexes, neuromuscular dysfunction, etc., resulting in insufficient voluntary respiration to maintain normal breathing, and at the same time, to minimize the occurrence of aspiration and pneumonia, it is necessary to give the patient tracheal intubation, invasive mechanical ventilation and other ways to assist ventilation. Tracheal intubation destroys the normal anatomical structure of the respiratory tract, which may lead to mechanical injury of the larynx and vocal cords, local ulcers, granulomas, etc. Mechanical stimulation of the tube may cause an inflammatory reaction of the laryngeal mucosa, leading to local swelling and pain and thus affecting the recovery of swallowing function [67]. Secondly, breathing and swallowing share the pharynx, and tracheal intubation may disrupt the normal breathing-swallowing coordination, interfere with the airway closure mechanism during swallowing, and prevent the normal vocal cord closure and laryngeal raising, thus affecting the smooth passage of food and increasing the risk of aspiration [68]. In addition, prolonged intubation and mechanical ventilation may weaken the neuromuscular function of swallowing-related muscles, further hindering the recovery of swallowing function [68]. Neurological dysfunction in stroke patients can lead to weakened or uncoordinated muscle strength of the pharynx, tongue, palate, and chewing, which impairs the ability to swallow food, thereby reducing the oral clearance rate and inducing aspiration. To a certain extent, aspiration reflects the severity of dysphagia in patients, and aspiration may lead to aspiration pneumonia, which significantly affects the prognosis and recovery. As a result, the recovery of swallowing function in patients with aspiration is more difficult, and the recovery process is slower. The aspiration risk management of PSD patients requires the cooperation of a multidisciplinary team, including clinicians, speech therapists, physical therapists, nutritionists, etc., to develop an individualized and comprehensive intervention plan.

5. Conclusion

This systematic review examined the recovery of PSD and identified that older age, lower BMI, bilateral stroke, higher NIHSS score, tracheal intubation, and aspiration were unfavorable factors for the recovery of swallowing function. The findings summarized above provide strong evidence to help nurses identify patients at high risk of poor PSD prognosis and support nurses to make accurate clinical decisions, such as which patients may need closer monitoring and more aggressive rehabilitation interventions. Thus, a personalized rehabilitation plan can be developed for patients to improve the efficiency and effectiveness of rehabilitation. However, this systematic review also has some limitations. Firstly, only six included studies utilized prospective cohort design, while most were retrospective. Retrospective studies inherently have some shortcomings in study design and interpretation of results. Secondly, the included studies employed varying evaluation methods, evaluation time, and rehabilitation measures for swallowing disorders. This heterogeneity made it challenging to compare the study results and consistent conclusions accurately. In addition, some of the influencing factors included in this study were only reported in 1–2 studies, so meta-analysis could not be performed. Future research in this area should strive to employ standardized, uniform measures of swallowing function evaluation. Additionally, more prospective studies are needed. Ultimately, the focus should remain on developing personalized rehabilitation therapies based on the identified clinical predictors of swallowing disorders recovery after stroke.

CRediT authorship contribution statement

Xiaoyan Jin: Conceptualization, Methodology, Resources, Data curation, Formal analysis, Writing – original draft, Project administration, Writing – review & editing. **Shaomei Shang:** Conceptualization, Project administration, Supervision. **HoiYee Tong:** Conceptualization, Validation. **Ming Liu:** Methodology, Writing – review & editing. **Dan Li:** Methodology, Resources, Data curation, Formal analysis. **Ying Xiao:** Conceptualization, Project administration, Supervision.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of competing interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. We confirm that we do not have any financial or personal relationships with other people or organizations that could inappropriately influence (bias) our work presented in this manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2025.02.002.

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