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Efficacy of Swallowing Resistance Exercise on Swallowing Function and Nutritional Status in Diabetic Elderly at Risk for Dysphagia: Randomized Controlled Study

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Abstract: Older people with type 2 diabetes mellitus (T2DM) are at increasing risk for dysphagia; therefore, this study was designed to investigate the protective effect of swallowing resistance exercise (SRE) on swallowing function (SF), nutritional status, and dysphagia risk in elderly individuals with T2DM. Sixty elderly patients with T2DM, at risk for dysphagia, were randomly allocated into an intervention group (received SRE; n=30) and a control group (n=30). The SRE programme consisted of alternative daily sessions of chin-tuck SRE (30% maximum chin-tuck strength intensity) for 12 weeks. The SF was assessed using the Swallow Difficulty Questionnaire (SDQ), nutritional status using the Mini Nutritional Assessment (MNA), and dysphagia risk using the Dysphagia Risk Assessment Scale, all evaluated pre- and post-intervention. The data were statistically analysed using paired t-tests and ANCOVA as appropriate. There were significant improvements in the intervention group: the SDQ score decreased by 56.48% ($P<0.001$), the MNA score increased by 23.28% ($P<0.001$), and the dysphagia risk decreased by 40.52% ($P<0.001$). In conclusion, the resisted chin-tuck swallowing exercise programme can prevent deterioration and improve swallowing function, nutritional status, and dysphagia risk in diabetic elderly who are at risk of dysphagia.

Keywords: Deglutition, Nutritional Status, dysphagia risk, Diabetes Mellitus, Elderly, Resistance Training

1. Introduction

Swallowing difficulty is a serious age-related health problem [1], affecting about 30–40% of individuals aged 65 or older [2]. The ageing process negatively and progressively affects swallowing function, even in asymptomatic older adults [3], predisposing many to swallowing difficulties and malnutrition [4]. Being elderly is a definite risk factor for swallowing difficulty, particularly in patients with chronic diseases [5].

The successful swallowing process requires proper sensitivity and coordination of the involved body structures, which are all negatively affected by progressive age-related changes in older adults [6]. The presence of comorbid conditions magnifies the impact of swallowing difficulties on an individual's health, leading to disrupted nutritional status and quality of life [7]. Diabetes is usually associated with dry mouth and reduced salivary flow rate that, in turn, alters normal speaking, chewing, and swallowing processes [8] and contributes to dysphagia [9]. Swallowing dysfunction in older adults predisposes them to eating restrictions, feelings of frustration and shame, all of which may result in social isolation [10]. Swallowing difficulty and dysphagia negatively affect an individual's self-esteem, social role functioning, and quality of life and increase the incidence of depression and social isolation [11], increasing the mortality risk [12].

The risk of malnutrition is a serious health concern in older adults with type 2 diabetes mellitus (T2DM) [13], especially in those affected with diabetes for more than 10 years [14]. Swallowing problems disturb the balance between food intake and nutritional requirements, resulting in malnutrition, a progressive reduction in lean body mass, and weakness of the swallowing muscles, which, in turn, worsens the problem [15].

The existence of multiple risk factors for developing swallowing problems and dysphagia (ageing, chronic diseases, surgical and pharmacological factors) necessitates providing individually tailored preventive and therapeutic procedures for older adults [16]. Management of swallowing problems and dysphagia requires a multi-disciplinary approach to treat pathology, control symptoms, and correct nutritional disturbance [17]. Adequate rehabilitative procedures are necessary to improve swallowing [18, 19] by strengthening swallowing muscles, using skill-based training, and performing graded swallowing exercises [18, 20].

Swallowing rehabilitation focuses mainly on correcting the altered swallowing physiology. Exercise training programmes enhance swallowing function and reduce dysphagia-related consequences. Several approaches are specifically aimed at improving swallowing function and achieving a normal, coordinated swallowing process, while others are directed towards strengthening the swallowing subsystems [19–33]. Despite the increased incidence of swallowing difficulties and related health hazards among older adults, it is still underestimated, not routinely managed, and a proper rehabilitation programme is not adequately provided [34, 35]. Therefore, more effective rehabilitation programmes are needed to eliminate nutritional disturbances, aspiration hazards, and morbidity in older adults with swallowing difficulties [16]. This study aimed to investigate the efficacy of the resistance-based swallowing 'chin tuck' exercise training programme as a preventive measure for swallowing function, nutritional status, and dysphagia risk in elderly individuals with diabetes.

2. Materials and Methods

2.1. Study design

The current study followed a pre-test post-test, parallel-arm, randomised controlled study design and adhered to the Declaration of Helsinki (1975), revised in 2000. Ethical approval was obtained from the Umm Al-Qura University Biomedical Research Ethics Committee (approval number: HAPO-02-K-012-2025-04-2625). The study procedures followed the Consolidated Standards of Reporting Trials (CONSORT) checklist [36] and were conducted at the Department of Medical Rehabilitation Sciences, Umm Al-Qura University. All participants provided written informed consent to participate in the study and publication of its results.

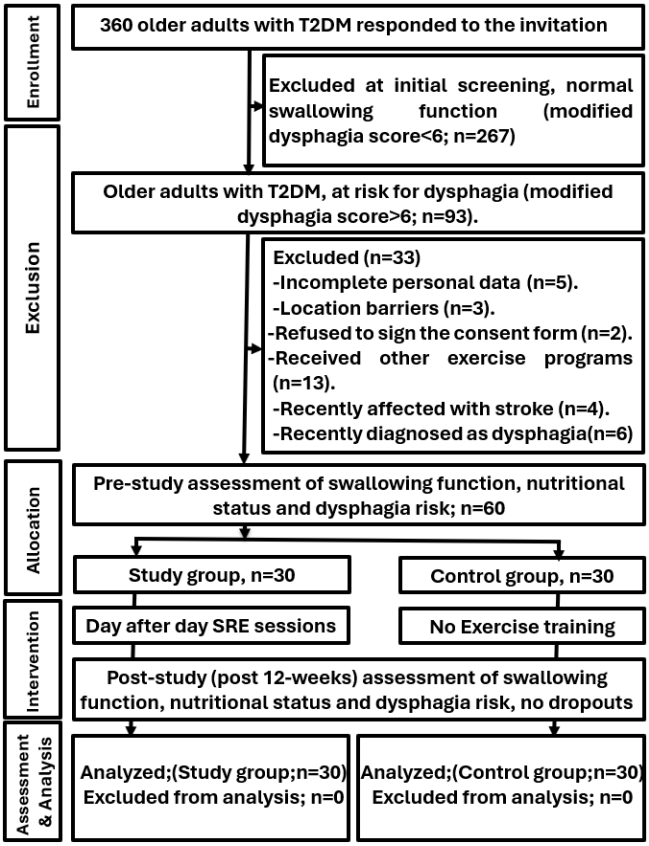
2.2. Participant recruitment

Older adults diagnosed with T2DM were recruited through social media platforms. Inclusion criteria included older adults with a sedentary lifestyle, aged 65–75 years old, diagnosed with T2DM (fasting blood glucose level ≥126 mg/dL, glycosylated haemoglobin (HbA1c%) ≥6.5%), at risk for dysphagia (scored 6 points or more on the modified dysphagia risk assessment scale) [37], was not previously diagnosed with dysphagia, ambulant elderly with exclusively oral feeding, and willing to participate in the study. Patients were excluded if they were already diagnosed with dysphagia, younger than 65 or older than 75 years old, participated in any previous swallowing resistance exercise programme or any structured exercise programme within the last 6 months, with recent infections or cardiovascular instability, periodontal diseases affecting participant's nutritional status, or who had factors limiting proper nutritional assessment such as amputation or ascites, those with cognitive impairment or previous dementia diagnostic reports, or those who refused to provide written informed consent.

Initially, 360 patients were screened by the same assessor to confirm eligibility based on the inclusion and exclusion criteria. Of them, 267 were excluded because they had normal swallowing function (scored less than 6 points on the modified dysphagia risk assessment scale), and 33 patients were excluded due to incomplete personal data (n=5), location barriers that affect regular participation (n=3), underwent other exercise training programmes within the last 2 months (n=7), or at the time of the study (n=6), had a recent neurological disorder (stroke, n=4), or recently diagnosed with dysphagia (n=6), or refused to provide written consent (n=2). In total, 60 participants (42 men and 18 women) underwent the pre- and post-study assessments and completed the study.

The G*Power software (version 3.1.9.4) was used to determine a suitable sample size: considering a prevalence of 17.5% for swallowing difficulties among patients with diabetes [36], a medium-large effect size (Cohen's f) of 0.8, a 0.05 precision value, a power of 0.95, and a two-group allocation, a total sample of 56 participants was required to clarify significant differences and achieve the target power. An additional 4 participants (7%) were included to compensate for any drop-offs or withdrawals.

Eligible participants were randomly assigned using the 'research randomiser' software (https://www.randomizer.org/) [38] by an independent statistician to the two groups: the control group (n=30: 20 men and 8 women) or the study group, which underwent an altyernative daily chin tuck-in exercise programme (n=30: 22 men and 8 women). To avoid selection bias and ensure assessor blinding, the independent statistician placed the randomly generated allocation concealments into sequentially numbered, opaque, sealed envelopes that were not opened until the pre-study assessments were completed (**Figure 1**). The nature of the study allows only blinding of assessors about the groups' allocation and treatment procedures. Given the visible nature of the swallowing resistance exercises, it was unavoidable that both participants and researchers were aware of the intervention.



T2DM-Type 2 diabetes mellitus, **SRE**-swallowing resisting exercise.

Figure 1. Patient's flow chart.

2.3. Data collection

All participants' demographic characteristics were initially evaluated (pre-study). Swallowing function, dysphagia risk, and nutritional status were assessed pre- (a day before starting the treatment programme) and post-study (3 days after completing the treatment programme) to avoid the acute post-training effects. Information regarding age, weight, height, body mass index, gender, marital status, educational status, diabetes duration, fasting blood glucose level, HbA1c%, number of daily medications, resting heart rate, systolic and diastolic blood pressure, and use of dentures was collected according to standard procedures.

All assessment procedures were scheduled at the same location, at the same time of day (8:00 am until 12:00 pm), and at the same atmospheric temperature (23°C). The same assessor evaluated variables to eliminate the inter-rater variability. A licensed therapist provided the treatment programme. Safety measures were considered throughout the study. Initial screening, close monitoring, objectively determining training parameters, and limiting training intensity to 30% of the maximum chin tuck strength (MCTS) were implemented to minimise the potential risks of neck muscle strain, excessive fatigue, discomfort, and dizziness. No adverse events were reported.

2.3.1. Dysphagia risk assessment

The dysphagia risk was evaluated using the Modified Dysphagia Risk Assessment Scale composed of 23 items, with a score ranging from 0, representing 'best response of rarely occurrence of the evaluated phenomena', to 3, indicating 'worst response of usually occurrence of the evaluated phenomena'. A score of 6 points or more was indicative of the risk for dysphagia [39, 40].

2.3.2. Swallowing function assessment

The swallowing function was evaluated according to the previously described protocol of Cohen and Manor [41]. Each participant was directed to complete the 15-item self-reported swallowing disturbance questionnaire (SDQ), composed of 5 questions to evaluate the oral phase and 10 questions to evaluate the pharyngeal phase. The first 14 questions were rated on a 4-point (0 to 3) scale, where 0 means no disturbance, 1 means single or no disturbances per month, 2 means 1 to 7 disturbances per week, and 3 means more than 7 disturbances per week. The last question was rated as yes or no. A score of 12.5 or more indicated the existence of swallowing disturbances.

2.3.3. Nutritional status assessment

Nutritional status was evaluated using the Mini Nutritional Assessment Short Form (MNA-SF) according to a previously described procedure [42]. The MNA-SF is a nutritional screening tool used to evaluate nutritional status and detect malnutrition or malnutrition risk in the elderly population by assessing changes in six domains over the past three months: food intake, weight loss, acute diseases or psychological stress, mobility status, neuropsychological problems, and body mass index. Each question was scored from 0 to 3, with a maximum total score of 30: 0–7 points indicate malnutrition, 8–11 indicate at risk for malnutrition, and 12–14 indicate normal nutritional status.

2.3.4. Exercise training intensity

Exercise training intensity was determined to allow consistent application of the resisted chin-tuck swallowing exercise, with well-controlled, clearly defined patient effort, as described by Smithard et al [23], with minor modifications. Maximum chin tuck strength (MCTS) was evaluated as follows: the patient was sitted comfortably for 10 minutes, with the neck positioned in a relaxed neutral position, then an inflated air-filled bladder (24–32 cm cuff) connected to a pressure gauge (Rossmax-GB102, China) through a flexible plastic catheter was positioned below the patient's chin (between the chin and the manubrium sterni) and was secured with a cotton neck strap. The participant was then instructed to exert maximal force during a maximal chin tuck against

the inflated air-filled bladder for 5 seconds, and to repeat the manoeuvre 3 times while watching the pressure gauge for feedback. The best trial reading was used to determine the MCTS. The individualised safe target training intensity was then calculated and set at 30% of the MCTS, because it is the safe submaximal effort level (intensity) according to Smithard et al. [23]. The MCTS was re-evaluated monthly, and 30% of its value was adjusted accordingly.

2.4. Interventions

All participants were directed to maintain their dietary habits, medication regimens, and daily activity levels throughout the study period. To ensure adequacy and consistency, participants' relatives/caregivers were educated and trained to provide standardised weekly reports on the participant's dietary intake, medication doses & adherence, and daily activities; the therapist reviewed these reports weekly. To ensure the adequacy of the provided reports, the therapist periodically (during sessions) asked participants about their dietary patterns and requested that they stabilise their dietary regimens and notify the therapist of any changes as soon as possible. Each participant was asked to recall their dietary regimen over the previous 24 hours before the training session. Medication intake was also monitored through regularly counting tablets and reviewing the prescribed medication lists. Participants were also asked to recall and report the activities they performed over the 24 hours before the training session. The reported activity levels of participants and caregivers were further compared with those obtained from personal wearable devices and smartphone activity-monitoring applications throughout the study. These verification procedures ensure the accuracy of the provided reports and ensure participants' adherence to the therapist's instructions during the study. No serious deviations or adverse events were recorded.

2.4.1. The swallow resisting exercise programme.

While assuming a relaxed setting position, starting with the head in neutral position, the participant was instructed to perform the chin tuck manoeuvre, gradually squeezing the inflated cuff between chin and sternum until reaching the individualised target training intensity (30% of the MCTS; guided via the pressure gauge manometer feedback) and hold the end position for 60 seconds. The resisted chin-tuck swallowing exercise training programme consisted of alternative daily sessions scheduled for 12 weeks. Each session included repeating this exercise 10 times, with a 60-second rest between successive repetitions. The participant was instructed to maintain quiet, nasal breathing throughout the session.

2.5. Statistical Analysis

Data were statistically analysed using SPSS 20.0 (IBM SPSS, Armonk, NY). The Shapiro-Wilk test, along with visual graphs and histograms, was initially used to assess data normality. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were reported as appropriate. Changes in the dependent variables within-groups were analysed using the paired t-test, while between-groups variabilities were analysed using ANCOVA as appropriate. A P-value < 0.05 was considered statistically significant.

3. Results

Sixty participants completed this study, and no serious events were reported. Their demographic characteristics are summarised in Table 1, with no statistically significant differences between groups pre-study. Also, there were no significant differences in dysphagia risk (P=0.62), swallowing function (P=0.13), and nutritional status (P=0.06) between groups pre-study (Table 2).

Post-study comparisons between groups revealed significant differences in dysphagia risk (Cohen's d=0.77, 95% CI: -12.92 to -10.69, P<0.001), swallowing function

(Cohen's d=0.52, 95% CI: -7.9 to -5.95, P<0.001), and nutritional status (Cohen's d=0.51, 95% CI: 1.13 to 2.3, P= 0.001) in favor of the intervention group (Table 2).

Within the intervention group, there were significant improvements in the evaluated variables post-study. The dysphagia risk score decreased by 40.52% (mean difference = 6.33±2.78, 95% CI: -7.37 to -5.29, P<0.001), the SDQ (swallowing function) score decreased by 56.48% (mean difference = 5.07±2.33, 95% CI: 4.2 to 5.94, P<0.001), and the MNA (nutritional status) score increased by 23.28% (mean difference = 2.0±1.8, 95% CI: 1.33 to 2.67, P<0.001) (Table 2).

Within the control group, the post-study results revealed significant increases in the dysphagia risk score (6.39%, mean difference = 0.83±1.09, 95% CI: 0.43 to 1.24, P<0.001), and SDQ score (2.34%, mean difference = 2.1±1.42, 95% CI: -2.63 to -1.57, P<0.001) (Table 2).

Table 1. Basic participants' characteristics in the intervention and control groups (Mean ± SD).

Variables	Intervention group (n=30)	Control group (n=30)	P value☼
Age (year)	66.27±1.8	66.8±1.86	0.26**
Weight (kg)	65.93±3.46	66.93±3.68	0.28**
Height (m)	1.64±0.05	1.64±0.03	0.65**
BMI (Kg/m2)	24.61±2.1	25.08±1.75	0.35**
Dysphagia risk	16.23±6.49	15.47±5.36	0.56**
Diabetes duration (year)	10.87 ± 1.36	10.53±1.93	0.44**
FBG (mg/dl)	166.8±8.79	167.1±6.97	0.88**
HbA1c %	8.29±0.37	8.22±0.42	0.5**
SBP (mmHg)	141.07± 4.47	142.87±3.44	0.09**
DBP (mmHg)	83.2± 4.24	83.77±3.65	0.58**
RHR (beat/min)	78.4± 6.87	79.0±8.71	0.77**
Gender (Women: Men)	8(26.7%): 22 (73.3%)	10(33.3%): 20 (66.7%)	0.58**
Hypertension (No: Yes)	8(26.7%): 22(73.3%)	9(30%): 21(70%)	0.78**
Using walking aids:(No: Yes)	13(43.3%): 17(56.7%)	16(53.3%): 14(46.7%)	0.44**
Use of Dentures (No: Yes)	23(76.7%):7(23.3%)	22(73.3%):8(26.7%)	0.77**
Smoking Status: Current: Past: Never	1(3.3%):9 (30%): 20 (66.7%)	5 (16.7%):1 (3.3%):24 (80%)	0.47**
Number of drugs used/ day: Less than 3: More than 3.	9(30%): 21(70%)	10(33.3%): 20(66.7%)	0.78**
Educational level/ status: Illiterate: Primary school: Secondary school: Higher education.	5(16.7%): 6(20%): 12(40%): 7(23.3%)	8(26.7%): 7(23.3%): 9(30%): 6(20%)	0.34**
Marital status: Married: Single	25(83.3%): 5(16.7%)	29(96.7%): 1(3.3%)	0.09**
Living Alone (No: Yes)	28(93.3%): 2(6.7%)	28(93.3%): 2(6.7%)	1.00**

☼-Level of significance at P<0.05, **-non-significant, **BMI**-Body mass index, **FBG**-Fasting blood glucose level, **HbA1c**-Glycosylated haemoglobin, **SBP**-Systolic Blood pressure, **DBP**-Diastolic blood pressure, **RHR**-Resting heart rate.

Table 2. Between-groups comparison of swallowing function, nutritional status, and dysphagia risk (Mean ± SD).

Variables		Intervention group (n=30)	Control group (n=30)	F-value	P-value✡
Dysphagia risk	**Pre**	16.23±6.49	15.47±5.36	0.25	0.62**
	Post	9.9±5.09	16.3±5.42	22.23	<0.001*
P-value✡		0.001*	<0.001*		
Swallowing function (SDQ score)	**Pre**	9 ± 2.33	8 ± 2.7	2.36	0.13**
	Post	3.93 ± 2.39	10.1 ± 2.88	81.38	<0.001*
P-value✡		<0.001*	<0.001*		
Nutritional status (MNA score)	**Pre**	9.7 ± 1.78	10.57 ± 1.76	3.6	0.06**
	Post	11.7 ± 1.44	10.43 ± 1.41	11.86	0.001*
P-value✡		<0.001*	0.35**		

✡-Level of significance at P<0.05, *-significant, **-non-significant, **SDQ**-The swallow difficulty questionnaire, **MNA**-Mini nutritional assessment questionnaire.

4. Discussion

Diabetes and ageing predispose older adults to dysphagia and malnutrition, resulting in harmful personal and social burdens [9]. The present study investigated the efficacy of a resisted chin tuck swallowing exercise training programme on swallowing function, nutritional status, and dysphagia risk in diabetic older adults without clinical dysphagia, demonstrating favourable effects of the prescribed rehabilitation programme. This low-burden programme of the resisted chin tuck swallowing exercise is a feasible preventive measure to preserve the swallowing function health and prevent nutritional deterioration among the older adults with T2DM who are at risk for developing dysphagia.

Anchoring the resisted chin tuck swallowing exercise programme to an objectively determined training intensity reduces within- and between-participant variability in strength training intensity, thereby enhancing the reproducibility and interpretability of the study outcomes. Standardising the training intensity at 30% of the MCTS as a safe submaximal effort level (intensity) following the guidelines of Smithard et al. [23] is a clinically important feature of the current study protocol. A limited number of the previously published protocols objectively quantified participants' efforts during the swallowing resistance exercises [23, 25, 31, 43, 44], but there was a lack of a clearly defined, objectively determined level of the resistance force (training intensity) produced by the patient during the swallowing resistance exercise training. Furthermore, because the swallowing exercise programme included only a limited number of simple exercises, participants' adherence was excellent, as reflected in the absence of dropouts.

Swallowing dysfunction and, subsequently, increased aspiration risk, even among asymptomatic older adults, occur with poorly compensated motor function [45]. Rehabilitation requires proper patient cooperation and can be directed either towards exercising the tongue, lips, jaw, and larynx musculatures or towards improving glottic closure function [46, 47]. A variety of rehabilitation programmes are available for people with swallowing problems and dysphagia [21–33]. Swallowing exercises can be used to maintain oropharyngeal muscle strength, thereby improving swallowing function in older adults [27].

Generalised skeletal muscle weakness, easily fatigability, and increased comorbidity burden are common age-related phenomena [48] that may limit the applicability of many therapeutic procedures in older adults suffering dysphagia or at risk for developing dysphagia [49], such as Shaker exercises [31]. Alternatively, a more focused,

easily applicable swallowing resistance exercise (chin tuck against resistance) is advisable, using an inflatable ball squeezed by the patient's chin against the anterior neck [21, 47].

The increased incidence of dysphagia in older adults can be attributed to weak supra-hyoid muscles, reduced upward and anterior laryngeal movements, diminished epiglottic depression, and upper oesophageal sphincter opening [47, 50]. Swallowing against laryngeal restriction is feasible and can significantly increase the strength of muscles responsible for the pharyngeal phase of swallowing in older adults [43].

The present results are consistent with previously reported findings showing that resistance exercise of swallowing structures can increase muscle strength and volume [51] and can improve the coordinated simultaneous action of the upper oesophageal sphincter opening, with the larynx moving upwards and forward during swallowing [52, 53]. Momosaki et al. reported that an adequate dysphagia rehabilitation programme can significantly improve oral intake and swallowing function in older adults with disturbed swallowing [54]. Previous studies examined the effects of swallowing strength training in different health situations, including neck exercises [52], tongue strengthening exercises [55], chin tuck against resistance [21, 23, 56], and have been shown to enhance swallowing mechanics through increasing the suprahyoid muscles strength, enhancing upper esophageal opening, and minimising the post-swallow aspiration incidence [52]. Additionally, Mohamed and Mahmoud recently reported that swallowing exercises had beneficial effects on swallowing abilities and dysphagia handicapping index, even in patients with head and neck cancer treated with radiotherapy. Limiting the types of exercises and controlling their variability, along with adequate methods, significantly increases the accuracy of study outcomes [57].

The present study clarified the favourable effects of the resisted chin-tuck swallowing exercise programme on the nutritional status of diabetic elderly individuals at risk for dysphagia. Previous studies reported that swallowing rehabilitation programmes were beneficial in reducing the incidence of malnutrition and pneumonia in older patients with dysphagia after head and neck cancer [26], stroke [29], and Parkinson's disease [58]. Furthermore, Crary et al. reported that the swallowing rehabilitation programme can provide long-term beneficial effects on nutritional outcomes, as evidenced by weight gain and increased oral intake during the 3-month follow-up in patients with chronic dysphagia [26, 28].

However, the present study's findings contradict those of Wakabayashi et al. [59], who examined the combined effects of tongue resistance exercise and manually resisted head flexion on swallowing difficulty (Eating Assessment Tool, EAT-10) and tongue pressure in older adults with dysphagia. They reported that the swallowing resistance training programme did not significantly improve dysphagia or tongue pressure in older people with dysphagia. Their study included frail elderly participants (mean age of 80 ± 7 years), as well as those with mild cognitive impairment and dementia, all of which may negatively impact their study results. Participants' adherence to treatment was self-reported, and the median adherence rate in the intervention group was 67%. Participants in the intervention group performed both tongue depression against resistance and head flexion exercise against subjectively determined manual resistance, allowing for wide variability in the applied resistance [59]. The non-supervised training session was performed 3 times per week for 3 months, included 2 sets of 10 repetitions, and lasted 10 seconds per repetition. Participants in the control group were allowed to perform resistance training autonomously throughout the study, which may have negatively affected the training-related differences between groups. Changes in dysphagia were evaluated using the EAT-10 scoring system, while the tongue pressure was assessed by measuring the maximum tongue pressure using a balloon instrument. The controversy between the present results and those of Wakabayashi et al. may be due to differences in participants' mean ages, the presence of

other pathological consequences, methodological variations in evaluation procedures, duration and frequency, and the type of resistance exercises performed.

Given the relatively low baseline deterioration in swallowing and nutritional functions in the present study sample, potential ceiling/floor effects for the SDQ, MNA, and dysphagia risk scales should be considered when interpreting results. Many participants had near-normal, slightly deviated baseline SDQ, MNA, and dysphagia risk scores. Hence, they had a limited range for measurable improvement (ceiling effect), and the intervention's effects may be underestimated. Nonetheless, the overall mildly deteriorated mean values of the SDQ, MNA, and dysphagia risk scores minimise the likelihood of detecting early changes within the control group (floor effect). Although there were significant differences between groups, results may be influenced by these measurement constraints. Future research should consider incorporating performance-based, functional, and more objectively evaluated variables with wider dynamic ranges to accurately detect changes in populations with minimal baseline deviations.

The progressive nature of the age-related and T2DM-related worsening effects on swallowing and nutritional measures, the lack of structured, continuous contact and monitoring (as in the study group), imperfectly controlled medication intake, dietary habits, and activity level in the control group may overestimate the between-group significance. However, future studies with long follow-up, objective control of contributing factors, and the incorporation of detailed safety monitoring and management protocols are needed to evaluate the observed beneficial training effects further.

This study has several limitations, including a relatively small sample, a relatively short study duration, a lack of long-term follow-up, limited recruitment strategies, a lack of control over participants' activities outside the intervention period, and limited blinding, thereby limiting the generalisability of the results. Future studies are required and should include combined online and other recruitment approaches to avoid selection bias and improve representativeness. Larger studies should also be conducted based on reference prevalence rather than effect-size expectations for the outcomes of interest. More research is also needed to explore the long-term follow-up effects; emphasis should be placed on adequately managing the reported limitations.

5. Conclusions

The resisted chin tuck swallowing training programme is effective in improving swallowing function and nutritional status and in reducing dysphagia risk in older adults with T2DM at risk for dysphagia. Swallowing resistance training should not only be utilised in populations with established dysphagia but also should be implemented as a preventive measure in populations who are at risk for developing dysphagia. It is important to acknowledge that the present results support the short-term preventive effects, as the long-term effects have not yet been explored. The present findings support the importance of conducting further research on the chin tuck swallowing resistance training as a potentially preventive approach, while emphasising the need for long-term studies with well-controlled non-specific influences.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Umm Al-Qura University Biomedical Research Ethics Committee (approval number: HAPO-02-K-012-2025-04-2625).

Informed Consent Statement: Informed consent was obtained from all participants in the study.

Data Availability Statement: Because of institutional policies, data will be available upon request.

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Conflicts of Interest: The author declares no conflict of interest.

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