J. Phys. Ther. Sci. 36: 273–277, 2024

The Journal of Physical Therapy Science

Original Article

Differences in cough strength, respiratory function, and physical performance in older adults with and without low swallowing function in the repetitive saliva swallowing test

Hideo Kaneko, PT, PhD[1)*], Akari Suzuki, PT, PhD[1)], Yoshiharu Nagai, PT, PhD[1)], Jun Horie, PT, PhD[2)]

[1)] Department of Physical Therapy, School of Health Sciences at Fukuoka, International University of Health and Welfare: 137-1 Enokizu, Okawa-shi, Fukuoka 831-8501, Japan
[2)] Department of Physical Therapy, Faculty of Health Sciences, Kyoto Tachibana University, Japan

Abstract. [Purpose] In older adults, the risk of aspiration pneumonia increases because of coexisting factors such as age-related decline in swallowing function, inefficient cough, reduced respiratory function, and poor physical performance. This study aimed to investigate the differences in cough strength, respiratory function, and physical performance in community-dwelling ambulatory older adults with and without low swallowing function. [Participants and Methods] In 225 community-dwelling ambulatory older adults, swallowing function (the repetitive saliva swallowing test, RSST), cough strength (peak cough flow), lung function (forced vital capacity, forced expiratory volume in 1 second/forced vital capacity), respiratory muscle strength (maximum inspiratory and expiratory pressures), and physical performance (30-second chair stand test and Timed Up and Go test) were evaluated. Participants with low swallowing function in RSST (low RSST group) were compared to age- and sex-matched participants without low swallowing function (control group). [Results] Peak cough flow and maximum inspiratory and expiratory pressures were significantly lower in the low RSST group (n=14) than the control group (n=14). [Conclusion] These preliminary results suggest that community-dwelling ambulatory older adults with low swallowing function in RSST might have lower cough and respiratory muscle strength, even if they have relatively preserved lung function and physical performance.
Key words: Deglutition, Aged, Cough

(This article was submitted Jan. 9, 2024, and was accepted Feb. 2, 2024)

INTRODUCTION

Aspiration pneumonia is the sixth leading cause of death in Japan[1)] and accounts for most cases of pneumonia in older adults[2)]. Aspiration by inhalation of oral contents or oropharyngeal secretions often results from swallowing disorders, dysphagia due to stroke, neurodegenerative disorders, or head and neck cancer. In addition, an age-related decline in swallowing function can cause dysphagia[3)], which has an estimated prevalence of 15% among community-dwelling older adults[4)]. Advanced age and frailty have been identified as risk factors for dysphagia[4)], and malnutrition and poor physical performance related to frailty have recently been reported as risk factors for dysphagia in ambulatory older adults[5)].

Likewise, reduced cough strength is a critical risk factor for the development of pneumonia[6)]. Maintaining effective cough strength is pivotal because pneumonia rarely ensures that coughing remains robust. This ability allows for the expulsion of the aspirated material, even in cases of aspiration resulting from dysphagia[7)]. Importantly, cough strength depends on

*Corresponding author. Hideo Kaneko (E-mail: hkaneko@iuhw.ac.jp)

respiratory function (lung volumes and respiratory muscle strength)[8]. Hence, if respiratory function declines, it may be more difficult to achieve effective cough strength. Reduced respiratory function in dysphagic patients who develop pneumonia was reported[9, 10].

However, in community-dwelling ambulatory older adults with age-related decline in swallowing function and without specific diseases[11], it is unclear which of the factors of cough strength, respiratory function, and physical performance are more likely to be diminished. Investigating factors associated with age-related decline in swallowing function might be helpful for better understanding of prevention of aspiration pneumonia in community-dwelling older adults. Therefore, the purpose of this study was to investigate the differences in cough strength, respiratory function, and physical performance between community-dwelling older adults with and without age-related decline in swallowing function.

PARTICIPANTS AND METHODS

This retrospective 1:1 matched case-control study was approved by the ethics review board of the International University of Health and Welfare (15-Ifh-02). Written informed consent was obtained from all participants.

Two hundred twenty-five older adults participating in senior club activities for preventive care at a community hall in Okawa, Japan from 2014 to 2017 were included in this study. They were asked to complete questionnaires about their medications and pneumonia experiences and were then evaluated for swallowing function, cough strength, respiratory function, and physical performance. Participants with pulmonary disease, neurological disease, head and neck cancer, airflow limitation, cognitive disorders impeding the comprehension of instructions, or a history of pneumonia were excluded. Subsequently, participants with low swallowing function were identified, using the repetitive saliva swallowing test (RSST), which is a screening test for aspiration. Finally, participants with age-related decline in swallowing function (low RSST group) and age (within two years)- and sex-matched participants without low swallowing function (control group) were analyzed.

The swallowing function was assessed using RSST, a safe screening tool. In the sitting position, the participants were asked to swallow their saliva as many times as possible in 30 seconds. According to a previous study, a measurement of two or fewer swallows within 30 s (<lower limit of normal) was considered indicative of dysphagia, categorized as abnormal (low RSST)[12].

Cough strength is measured as peak cough flow (PCF) in clinical settings, and reduced PCF is able to predict the development of pneumonia in patients with dysphagia associated with neurological and pulmonary diseases[9, 13]. PCF was measured using an oronasal mask connected to a portable peak flow meter (Access Peak Flow Meter, Philips Respironics, Parsippany, NJ, USA). The participants were seated and instructed to perform a volitional maximal effort cough following inspiration to total lung capacity. PCF measurements were repeated at least three times in the sitting position, and the highest value was adopted.

Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1)/FVC were measured using a spirometer (Spirobank, Medical International Research, Roma, Italy). All measurements were performed at least three times in the sitting position, according to the guidelines of the American Thoracic Society and European Respiratory Society[14]. The highest FVC and FEV_1/FVC were recorded. Airflow limitation was defined as FEV_1/FVC less than the lower limit of normal based on the Japanese Respiratory Society equations[15]. Percent FVC was calculated using the predicted values.

Respiratory muscle strength was assessed by measuring the maximum inspiratory pressure (MIP) and the maximum expiratory pressure (MEP) using a portable mouth pressure meter (MicroRPM, CareFusion, Hoechberg, Germany). MIP and MEP measurements were performed at least three times in the sitting position, starting from the residual volume and total lung capacity, respectively, according to the American Thoracic Society and European Respiratory Society guidelines[16]. The highest MIP and MEP values were also obtained. Percent MIP and MEP were calculated using predictive equations according to the Japanese Respiratory Society[17].

The 30-second chair stand test (30 s-CS) was used to test lower body functional performance[18]. Participants were instructed to perform as many chair stands as possible in 30 seconds, with their arms folded across the chest. After one practice trial was performed to ensure the proper form, the full stands completed in 30 seconds were counted.

The Timed Up and Go test (TUG) is widely used for the assessment of fall risk screening tests among older adults. The TUG measurements were performed twice using an armless chair[19]. The participants were asked to stand up, walk at a maximal speed for three meters, turn around a marker, walk back to the chair, and sit down. The fastest time was recorded.

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, NY, USA). Data are expressed as mean ± standard deviation or number. Normal distributions of variables were verified using the Shapiro–Wilk test. Differences between the two groups were evaluated using the unpaired t-test or Mann–Whitney U test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables. Cohen's d or r effect sizes for continuous variables and Phi effect size for categorical variables were calculated. The two-tailed significance level was set at 5%.

RESULTS

Three participants with pulmonary disease, five participants with neurological disease, and 23 participants with airflow limitation were excluded (Fig. 1). Of the remaining participants, 15 participants with low RSST were identified. After 1:1

matching for age and sex (except for one participant whose age did not match), 14 in the low RSST group and 14 in the control group were analyzed.

The participant characteristics, PCF, respiratory function, and physical performance are summarized in Table 1. Anthropometric data for the low RSST and control groups were similar. Among all participants, 11 had hypertension, 3 had dyslipidemia, cardiovascular disease, and osteoporosis. Additionally, 1 participant had diabetes, with no significant differences between the low RSST and control groups. None of the participants reported a history of pneumonia.

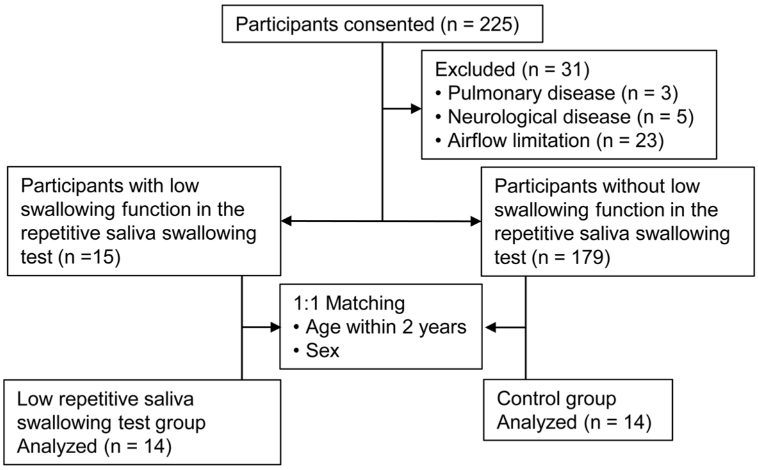

Fig. 1. Flow chart of the participants.

Table 1. Comparisons between older adults with and without low swallowing function on the repetitive saliva swallowing test in cough strength, respiratory function, and physical performance

	Total (N=28)	Low RSST group (n=14)	Control group (n=14)	Effect size
Sex (male/female) (n)	8/20	4/10	4/10	>0.01‡
Age (years)	81 ± 5	80 ± 5	80 ± 5	0.01
Height (cm)	152 ± 7	150 ± 8	153 ± 7	0.32
Weight (kg)	53.4 ± 8.2	52.8 ± 8.8	54 ± 7.7	0.14
BMI (kg/m^2)	23.2 ± 2.5	23.3 ± 2.9	23.1 ± 2.1	0.08
Hypertension (n)	11	4	7	0.22‡
Dyslipidemia (n)	3	1	2	0.19‡
Diabetes mellitus (n)	1	1	0	0.22‡
Cardiovascular disease (n)	3	1	2	0.12‡
Osteoporosis (n)	3	1	2	0.12‡
PCF (L/min)	249 ± 64	219 ± 41	280 ± 70*	1.08
FVC (L)	2.15 ± 0.64	2.06 ± 0.75	2.23 ± 0.53	0.27
FVC (%predicted)	89.5 ± 18.3	86.6 ± 21.7	92.4 ± 14.4	0.31
FEV_1/FVC (%)	78.6 ± 6.4	77.7 ± 7.5	79.4 ± 5.4	0.25
MIP (cmH_2O)	42.4 ± 20.6	32.6 ± 14.7	52.1 ± 21.4*	1.07
MIP (%predicted)	88.3 ± 43.0	69.3 ± 30.1	107.3 ± 45.4*	0.97
MEP (cmH_2O)	64.6 ± 29.0	53.6 ± 21.4	75.6 ± 32.0*	0.81
MEP (%predicted)	93.3 ± 36.9	79.9 ± 30.8	106.8 ± 38.5	0.77
30 s-CS (n)	14.8 ± 3.9	13.6 ± 4.4	15.9 ± 3.1	0.60
TUG (s)	7.8 ± 1.8	8.3 ± 2.3	7.3 ± 1.2†	0.12§

Values are mean ± standard deviation or number.
*$p<0.05$, †Mann–Whitney U test, ‡ Phi effect size, § r effect size.
RSST: repetitive saliva swallowing test; BMI: body mass index; FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 second; PCF: peak cough flow; MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure; 30 s-CS: 30-second chair stand test; TUG: Timed Up and Go test.

FVC, FVC %predicted, and FEV_1/FVC were lower in the low RSST group than in the control group; however, the differences were not statistically significant. The PCF, MIP, and MEP were significantly lower in the low RSST group than in the control group (d=1.07, d=0.97, and d=0.81, respectively). There were no differences between the two groups in the 30 s-CS and TUG tests.

DISCUSSION

Our main finding was that community-dwelling ambulatory older adults with low RSST had lower PCF, MIP, and MEP values than those without low RSST. This is consistent with the finding of reduced PCF in patients with dysphagia, although many of whom had cognitive or physical impairments were from a different population than the participants in this study[20]. Similarly, a previous finding that patients with dysphagia had lower PCF and MEP in head and neck cancer survivors[21] supports our finding. These preliminary results suggest that in community-dwelling ambulatory older adults with low swallowing function on RSST, cough and respiratory muscle strength may be more likely to decline than lung function and physical performance.

PCF (219 L/min) in the low RSST group was 22% lower than the control group. Reduced PCF (<160 L/min) in older adults with dysphagia and poor functional status significantly increases the risk of aspiration pneumonia[20]. In this study, all participants were independent in their daily lives, and participants with neurological disease or airflow limitation were excluded. As a result, all but one participant in the low RSST group had a PCF >160 L/min, and their lower body and balance functions were relatively well preserved. In other words, almost all the participants with low RSST maintained a certain level of PCF (>160 L/min) and physical performance. Relatively preserved PCF may explain why none of the participants in this study reported experiencing pneumonia.

The low RSST group had lower MIP (32.6 cmH_2O) and MEP (53.6 cmH_2O) than the control group. In a previous study on the risk factors for pneumonia in community-dwelling older adults[10], lower MIP (16.4 cmH_2O) and MEP (24.7 cmH_2O) of older inpatients with pneumonia than those (21.3 cmH_2O and 31.0 cmH_2O, respectively) of older inpatients without pneumonia was reported. These MIP and MEP values were lower than those of the low RSST group. One of the reasons for this is likely to be differences in participants because 31% of the non-pneumonia older adults in the previous study included older adults with stroke or limitations in activities of daily living. Differences in assessors and measurement devices should also be considered. In this regard, the MIP (69% predicted) and MEP (80% predicted) in the low RSST group can be considered not to be at a high risk of developing pneumonia.

Recently, it has been reported that aspiration pneumonia in older adults is diagnosed more often in relation to their general frailty than swallowing function[22]. Although we did not assess frailty, the participants in the low RSST group were unlikely to be frail because they voluntarily participated in senior club activities for preventive care, were not underweight (body mass index >18.5 kg/m^2), and had relatively preserved physical performance. From this point of view, the risk of aspiration pneumonia in the low RSST group was considered low, consistent with the no history of pneumonia. However, considering that cough and respiratory muscle strength are likely to decline along with swallowing function, to avoid increasing the risk of aspiration pneumonia, it would be helpful to assess these functions from the stage of independent living.

Our study has some limitations. First, low swallowing function in this study was not evaluated using the gold standard diagnostic tool, videofluoroscopic swallowing study because we used a simple and safe screening test for swallowing function. We were unable to confirm the objective findings of aspiration in our participants. Second, the present study had a cross-sectional design using annual survey data; thus, no causal relationship could be established between the observed outcomes. Finally, our findings, which were obtained from a small sample size study utilizing data from community-dwelling ambulatory older adults, may not be generalizable to other populations. Therefore, further large-scale studies are required to conduct well-designed research on community-dwelling older adults with low swallowing function levels.

These preliminary results suggest that community-dwelling ambulatory older adults with low swallowing function on RSST might have reduced PCF, MIP, and MEP even if they have relatively preserved lung function and physical performance. Further studies on swallowing, cough, and respiratory muscle functions with larger sample sizes are needed to generalize these findings.

Funding

This work was supported by the Japan Society for the Promotion of Science (JSPS KAKENHI Grant number JP26350842).

Conflicts of interest

None of the authors have any conflicts of interest associated with this study.

REFERENCES

1) Ministry of Health, Labour and Welfare: Japan: Summary of vital statistics: trends in leading causes of death. https://www.mhlw.go.jp/english/database/db-hw/populate/dl/E03.pdf (Accessed Oct. 14, 2023)
2) Teramoto S, Fukuchi Y, Sasaki H, et al. Japanese Study Group on Aspiration Pulmonary Disease: High incidence of aspiration pneumonia in community- and hospital-acquired pneumonia in hospitalized patients: a multicenter, prospective study in Japan. J Am Geriatr Soc, 2008, 56: 577–579. [Medline] [CrossRef]
3) Maeda K, Akagi J: Sarcopenia is an independent risk factor of dysphagia in hospitalized older people. Geriatr Gerontol Int, 2016, 16: 515–521. [Medline] [CrossRef]
4) Madhavan A, LaGorio LA, Crary MA, et al.: Prevalence of and risk factors for dysphagia in the community dwelling elderly: a systematic review. J Nutr Health Aging, 2016, 20: 806–815. [Medline] [CrossRef]
5) Tagliaferri S, Lauretani F, Pelá G, et al.: The risk of dysphagia is associated with malnutrition and poor functional outcomes in a large population of outpatient older individuals. Clin Nutr, 2019, 38: 2684–2689. [Medline] [CrossRef]
6) Ebihara S, Sekiya H, Miyagi M, et al.: Dysphagia, dystussia, and aspiration pneumonia in elderly people. J Thorac Dis, 2016, 8: 632–639. [Medline] [CrossRef]
7) Nakajoh K, Nakagawa T, Sekizawa K, et al.: Relation between incidence of pneumonia and protective reflexes in post-stroke patients with oral or tube feeding. J Intern Med, 2000, 247: 39–42. [Medline] [CrossRef]
8) Kaneko H, Suzuki A, Horie J: Relationship of cough strength to respiratory function, physical performance, and physical activity in older adults. Respir Care, 2019, 64: 828–834. [Medline] [CrossRef]
9) Bianchi C, Baiardi P, Khirani S, et al.: Cough peak flow as a predictor of pulmonary morbidity in patients with dysphagia. Am J Phys Med Rehabil, 2012, 91: 783–788. [Medline] [CrossRef]
10) Okazaki T, Suzukamo Y, Miyatake M, et al.: Respiratory muscle weakness as a risk factor for pneumonia in older people. Gerontology, 2021, 67: 581–590. [Medline] [CrossRef]
11) Jardine M, Miles A, Allen J: Dysphagia onset in older adults during unrelated hospital admission: quantitative videofluoroscopic measures. Geriatrics (Basel), 2018, 3: 66. [Medline] [CrossRef]
12) Oguti K, Saitoh E, Baba M, et al.: The repetitive saliva swallowing test (RSST) as a screening test of functional dysphagia (2) validity of RSST. Jpn J Rehabil Med, 2000, 37: 383–388 (in Japanese). [CrossRef]
13) Pitts T, Bolser D, Rosenbek J, et al.: Voluntary cough production and swallow dysfunction in Parkinson's disease. Dysphagia, 2008, 23: 297–301. [Medline] [CrossRef]
14) Miller MR, Hankinson J, Brusasco V, et al. ATS/ERS Task Force: Standardisation of spirometry. Eur Respir J, 2005, 26: 319–338. [Medline] [CrossRef]
15) Kubota M, Kobayashi H, Quanjer PH, et al. Clinical Pulmonary Functions Committee of the Japanese Respiratory Society: Reference values for spirometry, including vital capacity, in Japanese adults calculated with the LMS method and compared with previous values. Respir Investig, 2014, 52: 242–250. [Medline] [CrossRef]
16) American Thoracic Society/European Respiratory Society: ATS/ERS statement on respiratory muscle testing. Am J Respir Crit Care Med, 2002, 166: 518–624. [Medline] [CrossRef]
17) Suzuki M, Teramoto S, Sudo E, et al.: [Age-related changes in static maximal inspiratory and expiratory pressures]. Nihon Kyobu Shikkan Gakkai Zasshi, 1997, 35: 1305–1311 (in Japanese). [Medline]
18) Jones CJ, Rikli RE, Beam WC: A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport, 1999, 70: 113–119. [Medline] [CrossRef]
19) Podsiadlo D, Richardson S: The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc, 1991, 39: 142–148. [Medline] [CrossRef]
20) Choi J, Baek S, Kim G, et al.: Peak voluntary cough flow and oropharyngeal dysphagia as risk factors for pneumonia. Ann Rehabil Med, 2021, 45: 431–439. [Medline] [CrossRef]
21) Hutcheson KA, Barrow MP, Warneke CL, et al.: Cough strength and expiratory force in aspirating and nonaspirating postradiation head and neck cancer survivors. Laryngoscope, 2018, 128: 1615–1621. [Medline] [CrossRef]
22) Yoshimatsu Y, Melgaard D, Westergren A, et al.: The diagnosis of aspiration pneumonia in older persons: a systematic review. Eur Geriatr Med, 2022, 13: 1071–1080. [Medline] [CrossRef]