Neurological Sciences
https://doi.org/10.1007/s10072-022-05998-w

ORIGINAL ARTICLE

Relationship between dysphagia severity and head and neck proprioception in patients with neurological disorders

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Received: 12 November 2021 / Accepted: 5 March 2022
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Abstract

Purpose Theaim of this study was to examine the relationship between dysphagia severity and head and neck proprioception in patients with neurological diseases.

Methods Twenty-six patients with neurological diseases who received the modified barium swallowing study (MBSS) were included. Dysphagia severity was assessed with the penetration aspiration scale (PAS). Patients were divided into two groups according to their PAS scores as "with dysphagia" ($n=15$) and "without dysphagia" ($n=11$). Active range of motion (AROM) and muscle strength were measured. Proprioception measurement of the cervical region was performed with a laser marker placed on the head of the patients, and the deviation from the middle target was noted in centimeters.

Results There was no difference between groups in terms of gender, age, height, weight, diagnosis, AROM, and the muscle strength of the cervical region ($p>0.05$). A moderate, positive correlation was found between dysphagia severity and the results of proprioception in terms of neck flexion, extension, and left rotation ($r=0.48$, $p=0.01$; $r=0.58$, $p=0.002$; $r=0.42$, $p=0.02$, respectively). There was a statistically significant difference in proprioception measurements of neck flexion, extension, and left rotation between groups ($p<0.05$).

Conclusion In conclusion, patients' decreased head and neck proprioception is related to severe dysphagia. Therefore, a holistic approach should be followed for swallowing function, and head and neck proprioception should be considered in dysphagia management.

Keywords Deglutition · Deglutition disorders · Neurological diseases · Neurogenic dysphagia · Head and neck · Proprioception

Introduction

Dysphagia is the term that defines any deterioration during the transition of the food from the mouth to the stomach [1]. It is a serious condition that can be seen in all age groups and needs to be managed. It may cause serious complications including malnutrition, dehydration, recurrent lung infection and weight loss, or even mortality if an appropriate diet is not maintained [2]. Therefore, dysphagia should be defined in all aspects, and necessary interventions should be planned.

Swallowing function requires the coherent function of a complex system with sensory and motor components in which many muscles are involved. This system is closely related to the structure and functions pertaining to the head, neck, and trunk due to its connection to the skull, the shoulder girdle, and the pelvis [3]. Most steps of swallowing function occur in the cervical region [4].

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Published online: 09 March 2022

Many structures related to swallowing function, such as the suprahyoid and infrahyoid muscles, laryngeal constrictors, larynx, hyoid bone, and upper esophagus, are located in this region. The swallowing process occurring in the cervical region is a dynamic process provided by muscle activation. Mobility in the cervical region as a whole during normal swallowing and a decrease in the angle of the cervical lordosis were reported previously [5]. Therefore, the alignment of the head and neck should be provided statically and dynamically to maintain the dynamic process in the cervical region correctly and effectively [6].

Proprioception is the awareness of the movement and position of the joints based on the information obtained by the sensory receptor system [7]. This information is used for many purposes including stability of the joint, coordination, balance, and acuity of movement [8, 9]. The cervical region, where most of the steps of swallowing function occur, is a region rich in proprioceptor density [10]. Postural compensatory strategies involving the head, neck, and trunk, adjustments of bolus volume and viscosity, exercise practices involving the head, neck, and swallowing muscles in the process of dysphagia rehabilitation emphasize the importance of sensory feedback in swallowing function [11–13]. Along with exteroception, the proprioception sense is involved in the perception of the texture and size of the food in the mouth and the alignment of the head, neck, and trunk. Thus, it could be concluded that the sensory receptor system of the cervical region should be considered in the management of dysphagia.

In neurological diseases, there may be alterations in the processing of proprioceptive information, and body orientation may be impaired [14]. It was thought that proprioception, which is important in head and neck stabilization, may be important for swallowing function considering the contribution of the head and neck region on swallowing function. In the literature, there is no study investigating the relationship between dysphagia and head and neck proprioception in patients with neurological diseases. Therefore, the purpose of this study was to investigate the relationship between the severity of dysphagia and head and neck proprioception in patients with a neurological diagnosis.

Methods

Participants

The patients were informed about the study, and the informed consent form was signed by the patients who agreed to participate in the study. The inclusion and exclusion criteria were stated below:

Inclusion criteria

i. Being in the age range of 18–65 years
ii. Being diagnosed with a neurological disease
iii. Having a score of 24 and above from the Mini-Mental State Examination (MMSE) [15]
iv. Having an adequate head control [16]
v. Having been consulted with suspicion of dysphagia and having received the modified barium swallow study (MBSS)

Exclusion criteria

i. Having received any treatment related to the cervical area that could affect proprioception
ii. Having had any previous treatment for dysphagia
iii. Having had any previous surgical procedure that may affect the stabilization of the musculoskeletal system related to the spinal column and lower extremity
iv. Having any vision problems

Evaluation procedures

The following evaluations were applied to the patients included in the study. All evaluations were performed by a physical therapist who was blinded to the MBSS results.

A detailed history including diagnosis, age (years), height (cm), body weight (kg), background diseases, family history, and dominant side was recorded. The MMSE was used to determine the mental status of the patients. The test consists of a total of five main topics, namely, orientation, memory, attention, language, and visual-spatial skills. A minimum of 0 and a maximum of 30 points can be obtained from the test. Patients with a score of 24 and above which indicates "normal cognitive status" were included in the study [15, 17].

The MBSS is the gold standard method used in swallowing evaluation. It is an objective evaluation method to detect the presence of dysphagia [18]. The test begins with the preparation of the foods used in the test, the positioning of the patient, and the preparation of the fluoroscopy device. In order to evaluate the swallowing safety, different volumes of foods are prepared in liquid, pudding, and solid consistencies. The patient is positioned in a sitting position on a chair to observe the swallowing function in the lateral plane. The test is started with a minimal volume and continued by increasing the volume. Oral, pharyngeal, and esophageal swallowing physiology is evaluated with this examination. Penetration, aspiration, and residues in the oropharyngeal area are detected [19]. In our study, swallowing results for 5 ml liquid were chosen as a standard for statistical analysis. The reason for choosing this consistency and amount

is that the 5 ml liquid is the most appropriate amount and consistency to monitor physiological events during swallowing [20]. The penetration-aspiration scale (PAS) was used to determine the severity of dysphagia [21]. The reliability study of the Turkish version of the PAS was performed in 2012 [22]. PAS scores range between 1 and 8, where 1 shows "No penetration and aspiration," scores between 2 and 5 indicate "Penetration," and scores between 6 and 8 indicate "Aspiration." The higher the score, the higher the severity of dysphagia. For rank analysis, the patients were divided into two groups according to the PAS scores as the study group (PAS scores 2 to 8) and the control group (PAS score 1).

The active range of motion (AROM) in the cervical region was evaluated. The patients were asked to sit in an upright sitting position on a stool. Measurements were performed with a clinical goniometer (Baseline Evaluation Tools, USA) for flexion, extension, lateral flexion, and right and left rotation movements of the neck.

A digital hand dynamometer (Lafayette Instrument Company, USA) was used to measure the strength of the cervical flexor and extensor muscles [23]. The measurements were performed based on the muscle test positions, and the method is defined by Lovett [24]. First, patients were informed about muscle testing. In the measurement of the flexor muscle strength, the patient was asked to lie in the supine position. The lower thorax was stabilized in order not to disturb the measurements, and the measuring arm of the dynamometer was placed in the frontal region. Then, the patient was asked to raise their head in the flexion direction. In this position, the patient was asked to push the dynamometer as much as possible. In the evaluation of the extensor muscle strength, the patient was asked to lie in the prone position. The upper thoracic region was stabilized in order not to disturb the measurements, and the measuring arm of the dynamometer was placed in the occipital bone. Then, the patient was asked to raise their head in the direction of extension. In this position, the patient was asked to push the dynamometer as much as possible. The tests were repeated three times for each direction with a break of at least 1 min after each measurement. The average score of three measurements was recorded in Newton (N) for statistical analysis.

Cervical region proprioception measurement was performed with a laser marker placed on the patient's head [25, 26]. Figure 1 shows the laser pointer. The patient was asked to sit in a comfortable position in a chair with back support. A target (40 cm in diameter) consisting of concentric circles drawn at 1-cm intervals was placed in front of the patient on the wall at a distance of 90 cm, in the visual field. The equipment and the evaluation procedure were explained to the patient in detail before the evaluation. The laser pointer device was placed on the patient's head (Fig. 2). First, the laser pointer on the head was passively aligned to the midpoint of the target by the researcher. The patient was asked to concentrate on this position. For trial, the patient was asked to flex their head and then to reposition their head to the previous position with eyes closed. Then, three measurements were performed. Before each measurement, the laser pointer on the patient's head was passively aligned to the mid-target point by the researcher. After the patient felt the position, they were asked to actively repeat in the specified direction and try to return to the starting position as accurately as possible. The amount of deviation of the laser pointer from the middle target was measured in centimeters according to the corresponding circle. The average deviation score of three measurements was calculated in centimeters. The same measurements were performed for extension and right and left rotation of the head (Figs. 1 and 2).



Fig. 1 Laser marker device

Statistical analysis

G*Power 3.0.10 program was used to perform statistical power analysis at Hacettepe University, Faculty of Medicine, Department of Biostatistics. A total of 26 patients with a neurological diagnosis were included with 5% type 1 error margin and 83% statistical power conditions.

Statistical analyses were performed using the SPSS version 23 (Statistical Package for the Social Sciences) software. The compliance of the variables to normal distribution



Fig. 2 Cervical region proprioception measurement

was examined by visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk tests). It was determined that the data did not comply with the normal distribution. Descriptive analyses are given as frequency and percentage values for qualitative variables and, mean, standard deviation, minimum and maximum values for quantitative variables. The relationship between the severity of dysphagia and head and neck proprioception in patients was calculated using the Spearman test in nonparametric conditions. Correlation coefficients between 0.05 and 0.30 show low or insignificant correlation, 0.30 and 0.40 show low-medium, 0–40 and 0.60 show medium, 0.60 and 0.70 show good, 0.75 and 0.75 show very good, and 0.75 and 1.00 show excellent correlation [27]. Difference between two groups in terms of numerical variables was examined using the Mann–Whitney *U*-test in nonparametric conditions. Any *p*-value less than 0.05 was considered statistically significant.

Results

Twenty-six neurologically diagnosed patients with a mean age of 52.5 ± 10.8 years (min = 28, max = 65) were included in the study. According to the PAS score, 57.6% ($n = 15$) of the patients were in the study group, and 42.3% ($n = 11$) were in the control group. There was no statistically significant difference between groups in terms of demographic information ($p > 0.05$) (Table 1).

The differences between groups in terms of AROM and the muscle strength of the cervical region are given in Table 2. No difference was found between groups in terms of AROM measurements of the head and neck region ($p > 0.05$), except neck extension ($p = 0.02$). There was no statistically significant difference between groups in strength measurements of the cervical flexor and extensor muscles ($p > 0.05$).

A moderate, positive correlation was detected between PAS score and the results of proprioception in neck flexion, extension, and left rotation ($r = 0.48$, $p = 0.01$; $r = 0.58$,

Table 1 Comparison of the demographic information of the groups

	Study group ($n = 15$)		Control group ($n = 11$)		*p*
	Mean ± SD	Min–max	Mean ± SD	Min–max	
Age	55.1 ± 7.6	38–65	48.9 ± 13.6	28–65	0.36
Height	165.8 ± 8.2	150–180	168 ± 8.1	150–180	0.45
Weight	73.3 ± 16.3	52–110	72.5 ± 18	43–110	0.97
Gender	*n*	%	*n*	%	
Woman	8	53.3	5	45.5	0.76
Man	7	46.7	6	54.5	
Diagnosis					
Stroke	9	60	4	36.4	0.10
ALS	3	20	1	9.1	
PD	2	13.3	1	9.1	
MS	0	0	3	27.3	
Ataxia	0	0	1	9.1	
MG	1	6.7	1	9.1	
Dominant side	*n*	%	*n*	%	
Right	15	100	9	81.8	0.09
Left	0	0	2	18.2	

ALS, amyotrophic lateral sclerosis; *PD*, Parkinson's disease; MS, multiple sclerosis; MG, myasthenia gravis; *$p < 0.05$ significant difference was accepted

Table 2 Comparison of active range of motion and muscle strength of cervical region between groups

	Study group ($n=15$)		Control group ($n=11$)		p
	Mean ± SD	Min–max	Mean ± SD	Min–max	
AROM (°)					
Flexion	41.8 ± 10.4	23–70	48.1 ± 12.6	28–75	0.16
Extension	34.2 ± 11.4	20–55	46.8 ± 14.1	30–70	**0.02***
Right lateral flexion	32.2 ± 8.5	13–45	32.5 ± 9.8	18–45	0.85
Left lateral flexion	33 ± 8.6	12–45	39 ± 10.6	19–60	0.08
Right rotation	57.7 ± 14.3	40–90	65.9 ± 12.2	40–80	0.10
Left rotation	59. 9 ± 13.4	35–80	69.1 ± 8.9	50–80	0.07
Muscle strength (N)					
Flexor muscles	11.5 ± 7.2	0–26.6	14.8 ± 6.6	7–29.8	0.26
Extensor muscles	18.6 ± 10.7	0–37	21.2 ± 7.1	13–39.3	0.58

(°), degree; *N*, Newton; *$p<0.05$ significant difference was accepted

$p=0.002$; $r=0.42$, $p=0.02$, respectively), but no correlation was found in neck right rotation ($p=0.07$). The loss of proprioception inneck flexion, extension, and left rotation directions was statistically higher in the study group compared to the control group ($p>0.05$) (Table 3).

Discussion

In neurological diseases, there may be problems in the processing of proprioceptive information, and thus, body orientation may be impaired [14]. Considering the contribution of the head and neck structures and functions to swallowing function, it was thought that proprioception may be important for swallowing function. In the literature, there is no study investigating the relationship between dysphagia severity and head and neck proprioception in a group of patients with a neurological disease. In this study, we found a relationship between dysphagia severity and head and neck proprioception in patients with a neurological disease, and head and neck proprioception was worse in patients with inadequate airway protection.

In our study, patients with and without dysphagia were similar in terms of gender, age, height, weight, diagnosis distribution, dominant side, AROM, and the muscle strength of the cervical region. These findings could be considered as the one of the strengths of our study. Neurogenic dysphagia is defined as swallowing disorders occurring in patients with neurological diseases such as stroke, ALS, PD, or MS [28]; therefore, patients with various diagnoses were included in our study. Sensory problems in patients with a neurological diagnosis occur due to pathologies occurring in any region between peripheral receptors and the somatosensory cortex [14, 29–36]. Regardless of the affected area, all diseases cause problems in the sensory conduction system; therefore, they may cause proprioceptive losses [14, 30–36]. The similarity of the descriptive characteristics of the patients, including the distribution of the type of neurological diseases they have, increases the reliability of our results regarding relationships and comparisons. In addition, we evaluated cervical AROM and the muscle strength of the cervical region because they are important parameters in head and neck proprioception evaluation [37]. The similarity between groups in terms of cervical AROM, except neck extension, and neck flexor and extensor muscle strength allowed us to compare the groups in terms of neck proprioception efficiently.

Table 3 Comparison of proprioception measurement results between groups

Proprioception (cm)	Study group ($n=15$)		Control group ($n=11$)		p
	Mean ± SD	Min–max	Mean ± SD	Min–max	
Flexion	13.9 ± 6.3	7.3–32.6	8.2 ± 3.8	3.6–16	**0.01***
Extansion	20.5 ± 9.9	7.3–40	9.1 ± 6.5	2.3–22.6	**0.00***
Right rotation	15.9 ± 6.2	8–31	11.6 ± 6.6	4.6–22.3	0.07
Left rotation	18 ± 8.3	5.3–33.3	10.7 ± 4.7	5.6–19.3	**0.02***

*$p<0.05$ significant difference was accepted. The values indicated in the table show the amount of deviation from the midpoint while trying to find the starting position of the patient

This is the first study investigating the relationship between dysphagia severity and head and neck proprioception in patients with neurological diagnosis. In our study, we observed that there was a relationship between dysphagia severity and head and neck proprioception, and the severity of dysphagia increased as the head and neck proprioception decreased. A margin of error of 4–5 cm or more in proprioception measurement indicates that the sense of proprioception related to the cervical region is impaired [38, 39]. The deviation in all measured directions is greater than the normative data in our study group; however, the deviation in patients with dysphagia was significantly higher in the direction of head flexion, extension, and left rotation compared to the control group. Studies on head and neck proprioception have mostly been conducted in patients with chronic neck pain, whiplash injury, or headache [39, 40]. In these studies, it was emphasized that the muscle spindle density in the cervical region, which provides enrichment in terms of proprioceptive information, is high, and that it is an important region for sensorimotor control [10, 38–40]. Therefore, we thought that the proprioceptive mechanisms of the cervical region are also important for swallowing function. Many studies have shown that sensory input is important in every stage of swallowing function [3, 41–44]. It has commonly been interpreted that the sensory feedback provided due to the increase in bolus volume regulates the movements of peripheral structures associated with swallowing; therefore, brainstem modulation is not completely stereotypical, and it is also adjusted with sensory feedback [41, 42]. In a study conducted in patients with poststroke dysphagia, it was reported that there were significant sensory deficits in the laryngopharynx region in patients with dysphagia, and this situation was likely to contribute to the development of aspiration [43]. All these studies show how important sensory parameters are for effective and safe swallowing function. Considering the results of our study, it could be concluded that head and neck proprioception is very important to ensure the continuity of the head and neck posture during swallowing (static stabilization), to perceive the dynamic mobility in the cervical region during swallowing, and to maintain an appropriate alignment of the muscles by providing sensory input to the central nervous system (dynamic stabilization). We think that the similarity between groups in the proprioception measurements in the direction of right rotation may be due to the fact that the majority of the patients included in the study were right dominant.

We also think that the results of our study are very important in terms of dysphagia literature. An accurate and comprehensive evaluation and the development of an appropriate management program are necessary to minimize eliminate the negative effects of dysphagia [45]. When we look at dysphagia evaluations in the literatüre, it is seen that sensory parameters are mostly evaluated in terms of sensations in the oral, pharyngeal, and laryngeal regions [41, 42, 46, 47]. Based on our study results, it is shown that swallowing function is not only a function involving the oral, pharyngeal, and laryngeal regions but also the contribution of the cervical region is also significant. Therefore, we think that it is necessary to have a holistic approach for swallowing function, and head and proprioception evaluations could be added to dysphagia evaluations.

There are also some difficulties encountered during the execution of our study. The patient admission and evaluation stages of the study were carried out during the global COVID-19 pandemic [48]. Due to the risk of contamination, it was difficult for patients with a neurological disease to come to the hospital, which resulted in difficulties in patient recruitment. Thus, the present study was completed with 83% statistical power. Future studies, with more participants allowing comparisons according to different diagnoses, should be conducted.

Conclusion

This is the first study investigating and showing the relationship between dysphagia severity and head and neck proprioception in patients with a neurological diagnosis. The results of the study show that as the head and neck proprioception decreases, the severity of dysphagia increases. These results are very important in terms of dysphagia literature. Therefore, we think that a holistic approach should be followed to swallowing function, and evaluations regarding head and neck proprioception should be added to dysphagia evaluations.

Author contribution Conceptualization: MS and SSA. Formal analysis: SSA. Investigation: MS, ND, AAK, and SSA. Methodology: MS, ND, AAK, and SSA. Project administration: MS, ND, AAK, and SSA. Supervision: SSA. Visualization: MS and SSA. Writing — original draft preparation: MS. Writing — review and editing: MS and SSA.

Declarations

Ethical approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards (approval number = GO19/691).

Informed consent All participants signed an informed consent form.

Conflict of interest The authors declare no competing interests.

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