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ORIGINAL ARTICLE

Influence of handgrip strength on pharyngeal transit time in individuals with chronic obstructive pulmonary disease

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HIGHLIGHTS

- Study with 15 individuals of both sexes, with Chronic Obstructive Pulmonary Disease (COPD), and mean age of 65.7 years.
- Most of the subjects in this study had severe COPD, reduced HGS, balanced BMI, normal swallowing, and longer PTT.
- A significant, albeit weak, correlation was obtained between PTT and ND-HGS.
- The HGS variables and HGS asymmetry were not enough to be considered a risk for abnormal swallowing.

KEYWORDS
Pulmonary disease;
Chronic obstructive;
Deglutition disorders;
Hand strength;
Muscle weakness

Abstract
Objective: To investigate the relationship between Handgrip Strength (HGS), dysphagia classification, nutritional aspects, and Pharyngeal Transit Time (PTT) in subjects with Chronic Obstructive Pulmonary Disease (COPD).
Methods: Study based on the analysis of secondary data from a database. The sample comprised 15 COPD patients of both sexes and a mean age of 65.7 years. We collected information on HGS, videofluoroscopic swallowing study, Volume-Viscosity Swallow Test (V-VST), and Body Mass Index (BMI). We applied correlation, effect size, and logistic regression tests at the 5% significance level.
Results: Most individuals had severe COPD (66.7%), mean dominant HGS of 28.2, and non-dominant HGS of 25.3. Five subjects were malnourished, five were well-nourished, and five were obese. Most of them had normal swallowing (40%), normal V-VST results (60%), and PTT of 0.89 s (liquid) and 0.81 s (pudding-thick). There was no significant correlation between the swallowing classification and the other variables. We obtained a significant correlation ($p = 0.015$), though weak ($r = -0.611$), between non-dominant HGS and PTT. Regarding the binary logistic regression, HGS variables and HGS asymmetry were not enough to be considered a risk to clinically abnormal swallowing (V-VST).

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Conclusion: Subjects with COPD in this study had a longer PTT than reported in the literature for normal subjects and a weak correlation between PTT and non-dominant HGS. The variables related to muscle condition were not considered predictors for abnormal swallowing.
Level of evidence: 3.

Introduction

The World Health Organization (WHO) estimates that the Chronic Obstructive Pulmonary Disease (COPD) will be the third most common cause of death by 2030. It is a worldwide spread, high-morbidity, high-mortality, progressive, irreversible chronic respiratory disease[1] characterized by limited airflow. COPD causes countless systemic changes besides the pulmonary ones, such as lean mass loss and muscle dysfunction,[2,3] and reduces the peripheral muscle strength and the functions of everyday activities.[3]

Skeletal muscle dysfunction is characterized by atrophy, changed distribution of type I (slow-twitch) to type II fibers (fast-twitch), and reduced oxidative capacity, mitochondrial function, and capillarization. The change in muscle fiber type occurs in approximately one third of COPD patients.[4]

Muscle dysfunction may also importantly impact swallowing, in which pharyngeal muscles have a significant role,[5] including the mylohyoid and suprahyoid muscles in the hyoid upper and anterior excursion. More than half of the fibers in the suprahyoid muscles are of type II, whereas the mylohyoid has a higher percentage of type I fibers.[6] Reduced muscle mass affects the type I fibers more directly than type II, influencing the hyoid bone elevation speed in swallowing reflex.[7]

Time and coordination, involving muscle activity to transfer the food bolus from the mouth to the esophagus, are essential to maintain airway protection.[8] The literature suggests a correlation between chronic respiratory diseases and oropharyngeal dysphagia. For instance, studies demonstrate decreased laryngeal elevation and tongue strength and movement, delayed swallowing reflex, and changed breathing-swallowing coordination in COPD patients.[9–11] Abnormal swallowing in COPD pose an aspiration risk to such patients, worsening their quality of life, socialization, and well-being.[12]

Changes in respiratory physiology may particularly influence the Pharyngeal Transit Time (PTT) in swallowing. When this is affected, various health aspects may be impaired, such as the patient's nutritional and pulmonary condition, as a longer PTT may influence the total feeding time, increasing the risk of laryngotracheal aspiration.[13]

Currently, no studies address different forms of directly measuring pharyngeal muscle strength. However, Handgrip Strength (HGS) assessment is quite commonly used in different populations to evaluate their overall strength – which is directly related to chronic morbidities, musculoskeletal disorders, and multimorbidity.[14–16]

The skeletal muscle function has clinical and prognostic value. Hence, it must be measured and monitored in outpatient routine to assess COPD patients, although it is not a clinical practice.[4] Incorporating these procedures in hospital routine and screening helps investigate possible changes in COPD patients due to muscle weakness, thus raising their awareness.

Professionals in different fields who learn about changes resulting from COPD can take precautionary and protective measures regarding the patient's health and prevent aspiration and disease exacerbation episodes. The relationship between musculoskeletal disorders and abnormal swallowing symptoms highlights the need for multiprofessional interventions, assessing and rehabilitating the patient to aid their overall health status.

Hence, this study aimed to investigate the relationship between HGS, dysphagia classification, nutritional aspects, and PTT in COPD patients.

Methods

This quantitative, cross-sectional, retrospective, descriptive study with secondary data analysis was approved by the Human Research Ethics Committee of the originating institution (nº 1.724.626).

Sample

The sample encompassed all patients attended between March 2016 and May 2017 in the Multidisciplinary Program for Pulmonary Rehabilitation (PMRP, in Portuguese) at a University Hospital, having met the eligibility criteria. All subjects signed the informed consent form.

Individuals with a clinical and spirometric diagnosis of COPD[17] and complete data in the medical record database – i.e., HGS, Videofluoroscopic Swallowing Study (VFSS), Volume-Viscosity Swallow Test (V-VST), and Body Mass Index (BMI) – were included. Thus, 15 people of both sexes, aged 50–74 years, were eligible.

Procedures

Handgrip strength

The HGS was measured with a hydraulic hand dynamometer (Jamar®) in kilogram-force (kgf). The subjects remained seated, their arms parallel to the trunk, shoulders, forearms, and wrists in neutral rotation, and elbow at 90°. Three maximum isometric strength measures, with 1-min rest intervals, were taken from each arm. The highest measure was considered as the result. The normal values were obtained from the equations proposed by Novaes et al. to predict HGS.[18]

We calculated the HGS asymmetry between the hands, which provides additional information and indicates reduced muscle strength, even before muscle weakness occurs.[19] Taking the highest kgf values for each, we divided Non-Dominant HGS (ND-HGS) by dominant HGS (D-HGS). Values < 0.80 or >1.20 respectively indicated dominant and non-dominant asymmetry.[19,20]

VFSS

Subjects were examined at the Department of Radiology of the University Hospital by a speech-language-hearing pathologist experienced in the field, accompanied by a radiology technician. The liquid stimuli were prepared with Bariogel® (Cristália, Brazil), diluted in water at 20% weight and thickened with xanthan gum (Resource® ThickenUp® Clear®, Nestlé Health Science), mixing 12 mL of barium sulfate in 48 mL of water. The pudding-thick recipes required 12 mL of barium sulfate mixed into 48 mL of water, adding 1.8 g (one and a half measure) of the said thickener. Consistency reproducibility was assessed with the IDDSI flow test.[21] The 10 mL syringe test (Becton Dickinson model BD 303134) confirmed the liquid (IDDSI level 0 – thin liquid) and pudding-thick consistency (IDDSI level 4 – extremely thick liquid).

The subjects remained seated, foot flat on the floor, with lateral projection. The videofluoroscopic imaging was focused on the lips, hard palate, posterior pharyngeal wall, and bifurcation of the esophagus and airway, by the seventh cervical vertebra. The images were taken (Siemens - Iconos R200) in fluoroscopy mode at 30 frames per second, and the videos were recorded in Zscan 6 capture software. The swallowing variables were analyzed with Kinovea® software 8.20 (2012).

Three speech-language-hearing pathologists with at least 5-year experience analyzing VFSS assessed the swallowing biomechanics. They were blind to the research objectives, the subjects' identity, and the other judges' assessments. PTT was set based on the most recurrent timing taken by the evaluators. If PTT were different, the intermediate one was selected. The swallowing was classified into the five levels set by O'Neil,[22] according to the severity of the swallowing disorders.

The visual perceptual variables were analyzed with the scale described by Baijens et al.,[23] in which PTT is the time interval in seconds from the opening of the glossopalatal junction to the closure of the upper esophageal sphincter. Vallecular residue (residue in the vallecula after complete swallowing) was classified as 0 – no residue; 1 – residue filling up to 50% of the vallecula; 2 – residue filling more than 50% of the vallecula. Pyriform sinus residue (residue in pyriform sinus after complete swallowing) was classified as 0 – no residue; 1 – mild to moderate residue; 2 – severe residue, filling up the pyriform sinuses.

V-VST

The swallowing was clinically assessed with the V-VST, whose objective is to define swallowing based on its efficiency (i.e., the capacity to swallow the calories and water necessary to the person's nourishment and hydration) and safety (i.e., the capacity to swallow without aspiration risks). During the assessment, the subject remained seated, and the evaluator offered different food consistencies, following the order required in the protocol. The following clinical signs were observed: cough, voice change, lower saturation, oral escape, oral residue, multiple swallowings, and pharyngeal residue. The patients who presented with one or more signs of impaired swallowing efficiency and/or safety were considered to have abnormal swallowing.[24]

BMI

The subjects' BMI was calculated to analyze their nutritional status and better characterize the sample, classifying them based on the COPD patient classification.[25]

Statistical analysis

The data were tabulated and analyzed with the Statistical Package for the Social Sciences (SPSS), version 26.0 (IBM Corporation, Armonk, NY, USA). The Shapiro–Wilk test was applied for the normality of data distribution; in case of non-normal results, they were transformed into natural logarithm.

The interrater agreement analysis was based on the Kappa agreement coefficient (for categorical and ordinal variables) and the intraclass correlation coefficient (for numerical variables).

The correlation between the variables was analyzed based on D-HGS, ND-HGS, HGS asymmetry, swallowing classification, sex, BMI, and PTT. We also distributed the V-VST classifications by D-HGS, ND-HGS, and HGS asymmetry, and analyzed the distribution of D-HGS, ND-HGS, HGS asymmetry, and PTT by degrees of COPD with the Mann–Whitney *U* test. The correlations between the variables were statistically treated with the Pearson correlation coefficient, and the sample effect size was calculated with Cohen's d test. A binary logistic regression was made, considering V-VST as a dependent variable and D-HGS, ND-HGS, and HGS asymmetry as independent variables.

The significance level was set at 5% ($p < 0.05$).

Results

The records of 15 people aged 50–74 years of both sexes were included in the study. The general characteristics are described in Table 1. There was no significant presence of vallecular or pyriform sinus residue, as only 2 (12.5%) individuals had liquid and pudding-thick vallecular residue. The interrater analysis revealed a significant agreement for the swallowing biomechanics variables in both consistencies.

The relationship between HGS and nutritional issues is shown in Table 2.

The analysis revealed a small sample effect size for the relationship between dominant HGS and BMI, with n of 0.100 (necessary estimate of 616 individuals); between non-dominant HGS and BMI, with n of 0.394 (estimate of 38 individuals); and between BMI classification and dominant HGS classification, with n of 0.194 (estimate of 160 individuals). It also showed a medium effect for BMI classifi-

Table 1 Study sample characteristics.

Variables	
Age (years), mean + SD	66.1 + 6.4
Males, n (%)	9 (60.0)
GOLD	
Moderate, n (%)	5 (33.3)
Severe, n (%)	10 (66.7)
D-HGS (kgf), mean + SD	28.2 + 5.4
D-HGS (% predicted), mean + SD	85.1 + 13.2
D-HGS classification	
Normal, n (%)	1 (6.7)
Reduced, n (%)	14 (93.3)
ND-HGS (kgf), mean + SD	25.3 + 5.8
ND-HGS (% predicted), mean + SD	83.4 + 22.7
ND-HGS classification	
Normal, n (%)	4 (26.7)
Reduced, n (%)	11 (73.3)
BMI (kg/m^2), mean + SD	24.3 + 4.9
BMI classification	
Malnourished, n (%)	5 (33.3)
Well-nourished, n (%)	5 (33.3)
Obese, n (%)	5 (33.3)
O'Neil	
Discrete/moderate dysphagia, n (%)	1 (6.7)
Discrete dysphagia, n (%)	2 (13.3)
Functional swallowing, n (%)	6 (40.0)
Normal swallowing, n (%)	6 (40.0)
V-VTS	
Normal, n (%)	9 (60.0)
Impaired safety, n (%)	2 (13.3)
Impaired efficiency, n (%)	3 (20.0)
Impaired safety and efficiency, n (%)	1 (6.7)
PTT	
Liquid (s), mean + SD	0.89 + 0.36
Pudding-thick (s), mean + SD	0.81 + 0.19

n, number of subjects; GOLD, Global Initiative for Chronic Obstructive Lung Disease; D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; BMI, Body Mass Index; V-VST, Volume-Viscosity Swallow Test; PTT, Pharyngeal Transit Time; s, seconds; SD, Standard Deviation.

cation and non-dominant HGS, with n of 0.584 (estimate of 14 individuals).

The data concerning the correlation between dysphagia classification (O'Neil), sex, HGS classification, and nutritional issues are seen in Table 3.

The correlation between dominant and non-dominant HGS and PTT for liquid and pudding-thick consistencies is shown in Table 4.

We also analyzed the sample effect for the correlation between PTT and HGS. There was a small effect for the relationship between liquid PTT and D-HGS, with n of 0.279 (estimate of 78 individuals); liquid PTT and ND-HGS, with n of 0.187 (estimate of 175 individuals); pudding-thick PTT and D-HGS, with n of 0.288 (estimate of 73 individuals). It also showed a medium effect for pudding-thick PTT and ND-HGS, with n of 0.597 (15 individuals).

The association between HGS and swallowing safety and efficiency is shown in Table 5.

Table 2 Correlation between handgrip strength, handgrip strength asymmetry, nutritional issues, and pharyngeal transit time for liquid and pudding-thick consistencies.

Variables	R	*p*-value
Absolute values		
D-HGS × BMI	0.021	0.939
ND-HGS × BMI	0.395	0.145
D-HGS × HGS asymmetry	−0.406	0.133
ND-HGS × HGS asymmetry	0.602	0.018[a]
PTT Liquid × BMI	−0.298	0.281
PTT Pudding-thick × BMI	−0.261	0.347
PTT Liquid × HGS asymmetry	−0.444	0.098
PTT Pudding-thick × HGS asymmetry	−0.365	0.182
Classifications		
BMI × D-HGS	−0.327	0.234
BMI × ND-HGS	−0.554	0.032[a]

HGS, Handgrip Strength; D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; BMI, Body Mass Index; PTT, Pharyngeal Transit Time; Statistical test, Pearson correlation.

[a] Significant values $p < 0.05$.

Table 3 Correlation between dysphagia classification, sex, handgrip strength classification, and nutritional classification.

Variables	O'Neil classification	
	R	*p*-value
Sex	−0.339	0.217
D-HGS classification	−0.040	0.887
ND-HGS classification	−0.250	0.369
BMI classification	0.462	0.083

D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; BMI, Body Mass Index; PTT, Pharyngeal Transit Time; Statistical test, Pearson correlation.

[a]Significant values $p < 0.05$.

The association between the degrees of COPD and HGS variables, HGS asymmetry, and PTT is shown in Table 6.

A binary logistic regression analysis for these associations investigated whether the HGS and its asymmetry would be risk predictors of abnormal swallowing based on the V-VST. However, the variables were not significant to construct the prediction model.

Discussion

Conditions such as malnutrition and obesity are associated with a high risk of mortality.[26] Studies have reported that the nutritional status significantly worsens the pulmonary function, increasing energetic expenditure. This may occur due to hypermetabolism, which results from more active respiratory muscles, requiring more oxygen.[12,26]

The sample's BMI distribution was balanced, although the literature suggests that all nutritional statuses may consume micronutrients inadequately.[26] Malnutrition is common in COPD and closely related to age.[12]

Skeletal muscle strength measures in COPD patients vary according to the severity of the disease and criteria used to

Table 4 Correlation between handgrip strength and pharyngeal transit time for liquid and pudding-thick consistencies.

Variables	Liquid PTT		Pudding-thick PTT	
	R	*p*-value	R	*p*-value
D-HGS	0.280	0.312	−0.289	0.297
ND-HGS	−0.188	0.503	−0.611	0.015[a]

D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; PTT, Pharyngeal Transit Time; Statistical test, Pearson Correlation.
[a] Significant values $p < 0.05$.

Table 5 Distribution (mean and standard deviation) of the association between the Volume-Viscosity Swallow Test classifications and dominant and non-dominant handgrip strength and handgrip strength asymmetry.

Variables	D-HGS	ND-HGS	HGS asymmetry
V-VST	mean (SD)	mean (SD)	mean (SD)
Normal	28.2 (±5.8)	25.3 (±5.8)	0.92 (±0.21)
Impaired safety	29.0 (±2.8)	27.0 (±8.4)	0.92 (±0.20)
Impaired efficiency	27.3 (±8.3)	24.6 (±8.0)	0.89 (±0.02)
Impaired safety and efficiency	29.0	24.0	0.82

V-VST, Volume-Viscosity Swallow Test; D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; SD, Standard Deviation.

Table 6 Distribution of frequency and association between dominant and non-dominant handgrip strength, handgrip strength asymmetry, liquid and pudding-thick pharyngeal transit time, and the degrees of chronic obstructive pulmonary disease.

Variables	Moderate GOLD Median (percentile)	Severe GOLD Median (percentile)	*p*-value
D-HGS	29.0 (24.5–30.5)	28.0 (22.7–34.5)	0.859
ND-HGS	24.0 (20.5–31.5)	25.0 (19.5–30.7)	0.953
HGS asymmetry	0.90 (0.80–1.03)	0.91 (0.85–1.02)	0.768
Liquid PTT	0.90 (0.62–1.10)	0.78 (0.60–1.19)	0.679
Pudding-thick PTT	0.80 (0.74–0.86)	0.83 (0.64–1.04)	0.859

D-HGS, Dominant Handgrip Strength; ND-HGS, Non-Dominant Handgrip Strength; PTT, Pharyngeal Transit Time; Statistical test – Mann-Whitney *U* test.
[a]Significant values $p < 0.05$.

establish the dysfunction. Up to one third of COPD patients are estimated to have changes in muscle function in different muscle groups, including reduced strength, resistance, and power and increased fatigability.[4] In this paper, most subjects had reduced dominant and non-dominant HGS, with means of 28.2 and 25.4, respectively. Muscle mass depletion, associated with functional skills and muscle strength, is largely responsible for negative effects of malnutrition.[12,26] Moreover, reduced muscle strength results directly from skeletal muscle mass loss, which is related to the loss of oxidative phenotype and not to the loss of muscle resistance. Hence, reduced muscle mass in COPD is also characterized by intrinsic muscle changes.[27]

The hand's gripping capacity is a complex task requiring the coordination of many motor units, and the quality of this coordination critically determines the strength the person can attain.[20] Also, the individual variations in the grip strength capacity are closely associated with the different markers that reflect neural function and brain health.[19,20] This coordination complexity may be also related and extrapolated to the swallowing dynamics, which, as well observed in the literature,[8–11] requires great coordination and precision.

Thus, the sample was mostly classified with normal or functional swallowing.[22] This can be explained by the lack of COPD exacerbation in the sample, despite its moderate and severe degrees.

This sample had a mean PTT of 0.89 s in liquid and 0.81 s in pudding-thick consistency (Table 1). The literature varies greatly regarding PTT with liquids in normal subjects, ranging from 0.69 and 0.71 s for 5 and 20 mL[28] to 0.23 s for 5 and 10 mL.[11] As for thick liquids, it ranges from 0.77 s for 5 mL[29] to 0.20 s for 10 mL,[30] besides 0.22 s for 10 mL of honey-thick liquids[30] and 0.26 s for 5 mL and 0.25 s for 10 mL of pudding-thick consistency.[11]

Regarding COPD patients, the literature reports PTT of 0.27 s,[11] 1.44 s,[10] and 1.18 s[9] for pudding-thick consistency. For liquid consistency, it reports 0.76 s for 5 mL;[9] 1.32 s for 5 mL and 1.25 s for 10 mL;[10] and 0.29 s for 5 and 10 mL.[11] Discussing these findings poses a challenge, given the methodological difference in the literature regarding both the amount tested (mL) and PTT spatial measuring concepts.[9–11,27–30]

The sample's PTT values were higher than those predicted in the literature for normal subjects without swallowing complaints.[28–30] Although some studies in the literature diverge regarding PTT definitions, the spatial markings used in this study near those in other ones.[28,29]

The sample's longer PTT may be due to insufficient subglottal pressure – these patients had a reduced expiratory flow, which is expected in the disease.[11] Also, longer PTT in liquid consistency can be explained by the need for greater neuromotor control[13] and the decreased sensitivity and motor deficit.[8] This finding differs from other studies, which report that the higher the food bolus density, the longer the PTT and the upper esophageal sphincter opening duration.[10,30]

In the literature, studies report longer PTT in stable COPD patients than in control groups.[9–11] This may be related to delayed swallowing reflex and lingual and pharyngeal peristaltic problems in people with the disease[10,11] – although this is also influenced by PTT spatial delimitation.

Longer PTT is also related to the duration of both vocal fold closure and hyoid movement. Hence, both variables are increased, possibly causing aspiration during swallowing if the vocal fold does not close properly.[11] These may be related to muscle weakness, as the expected swallowing events depend on this region's adequate muscle function and laryngeal elevation to work properly. Swallowing activates different hyolaryngeal muscles, contracting the suprahyoid muscles.[6,31] For instance, the geniohyoid muscle has a greater capacity to move the hyoid anteriorly, while the mylohyoid muscle moves the hyoid upward[31] and the long pharyngeal muscles participate in hyoid excursion.[6]

The literature suggests that the suprahyoid and thyrohyoid muscles are the main ones responsible for opening the upper esophageal sphincter.[31] Therefore, more than half of the suprahyoid muscle fibers are fast-twitch ones, which are influenced by less muscle mass and diminishes hyoid bone elevation speed in swallowing reflex,[7] possibly changing PTT in COPD patients. Also, with age, muscle atrophy changes the swallowing function, as observed in recent studies reporting changed composition – changes in muscle fiber type – in tongue, geniohyoid, and pharyngeal constrictor muscles.[32,33] These may significantly decrease the swallowing safety and efficiency process.[10]

Hence, we hypothesized an association between PTT and HGS in COPD patients. However, despite the significant ND-HGS and PTT values, the correlation between them was weak. Dominant hands should have higher values than non-dominant ones,[18] possibly related to its lesser use. Thus, the non-dominant hand can be a better muscle weakness marker. The literature reports that[27] such inactivity may be associated with fast skeletal muscle and functional capacity loss, which can be related to pharyngeal musculature.

Few studies relate muscle issues to swallowing in COPD patients. However, many studies report muscle issues in people with Parkinson's Disease (PD).[34,35] Studies evaluated PD patients after death, reporting muscle fiber atrophy and motor neuron degeneration in the pharyngeal region, contrasting with healthy individuals.[34] Spatial and temporal swallowing kinematics are influenced by differences in the pharyngeal region and, possibly, by muscle weakness.[35] Fewer type II fibers and more type I fibers were also observed in corpses. This may suggest functional changes in these muscles' intrinsic strength capacity, decreasing pharyngeal contraction strength and speed – which may be mainly due to their atrophy and transformation from fast- to slow-twitch.[34]

Hence, it was important to further investigate whether body muscle asymmetry – and possibly pharyngeal muscle asymmetry – could interfere with food bolus PTT. Indeed, HGS asymmetry has been studied as a possible marker for neuromuscular functioning deficits, unbalancing muscle strength.[19,20] It has been studied in PD patients, whose hand dominance is related to the hemibody with disease onset impairment and greatest change. Thus, left-handed people tend to have more severe changes on their left side.[36,37] However, no significant relationship was found between swallowing and HGS asymmetry in this study.

Furthermore, HGS asymmetry may influence the person's health status, including functional incapacity, low cognitive functioning, and early mortality.[19,20] This sample's HGS and HGS asymmetry results were not enough for the prediction model – i.e., they were not risk predictors for swallowing changes based on the V-VST.

COPD predisposes to comorbidities and symptomatic effects, which increase as the disease grows worse. Symptomatic effects progressively diminish the peripheral and respiratory muscle strength and function, affecting everyday activities and the quality of life.[38]

This study has some limitations, including the number of subjects, the lack of a control group with healthy adults, and the lack of literature on the relationship between the variables we analyzed. Hence, we suggest further studies be conducted considering these issues.

Conclusion

Most subjects in this study had severe COPD, reduced HGS, balanced BMI, normal swallowing, and longer PTT – which tend to change, affecting the person's overall health status and the severity of the disease.

A significant though weak correlation was found only between PTT and ND-HGS. HGS and HGS asymmetry were not enough to be considered a risk for abnormal swallowing.

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Conflicts of interest

The authors declare no conflicts of interest.

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