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ORIGINAL ARTICLE

Relationship between Tongue Pressure and Nutritional Status in Patients Undergoing Maintenance Hemodialysis: A Single-center Cross-sectional Study

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Objectives: This study aimed to investigate tongue pressure in patients undergoing maintenance hemodialysis (MHD) and identify factors associated with tongue pressure, such as nutritional status and sarcopenia components. **Methods:** This cross-sectional study included 80 outpatients undergoing MHD at our hospital between February and August 2024. Tongue pressure was measured using a tongue pressure measuring device. Patients were divided into groups of low tongue pressure (<30 kPa) and high tongue pressure (≥30 kPa). The geriatric nutritional risk index (GNRI) and the nutritional risk index for Japanese hemodialysis patients (NRI-JH) were used as nutritional indicators. To identify factors strongly associated with tongue pressure in MHD, a multiple regression analysis was performed, with tongue pressure as the dependent variable. **Results:** The median age of the participants was 81.0 years. The mean tongue pressure was 29.0 kPa, and 58.8% of the patients had tongue pressure less than 30 kPa. Tongue pressure was significantly lower in the oldest age group (≥85 years) than in the younger groups (≤64 years and 65–74 years). Significant correlations were noted between tongue pressure and age, serum albumin, skeletal muscle mass index, phase angle, and handgrip strength. In the multivariate analysis, age, GNRI, and handgrip strength were independent predictors of tongue pressure. **Conclusions:** This study revealed that age, handgrip strength, and GNRI were independently associated with tongue pressure in patients undergoing MHD. These factors may be used as indicators of tongue pressure in patients undergoing MHD.

Key Words: hemodialysis; nutritional status; sarcopenia; tongue pressure

INTRODUCTION

The tongue is a versatile and structurally complex muscular organ essential for swallowing. It undergoes a series of precisely timed shape changes to form the bolus and propel it from the oral cavity to the pharynx.[1] Tongue muscle strength is the primary driving force during chewing and swallowing,[2] and it may lead to inadequate oral intake and subsequent malnutrition if impaired.[3] Tongue pressure measurement is an objective method for evaluating tongue muscle strength[4] and swallowing muscle strength.[5] Studies on community-dwelling older individuals have found a correlation between tongue pressure and swallowing disorders,[6] indicating that understanding the factors contributing to reduced tongue pressure in healthy older individuals could help prevent age-related swallowing disorders.[7] Previous studies have reported an association between tongue pressure and age,[7–11] indicating that age-related changes in tongue function can affect swallowing safety.[9] Nutritional status is also associated with tongue pressure,[3,12] and recent systematic reviews and meta-analyses have found that individuals with sarcopenia have lower tongue pressure than those without it.[4,13]

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Japan's aging population is increasing and so is the number of older patients with chronic kidney disease (CKD) requiring renal replacement therapy (RRT).[14] The 2020 survey of patients on chronic dialysis in Japan reported an average age of 69.40 years, with a rising trend.[15] Nutritional issues in older patients undergoing dialysis include protein-energy wasting (PEW) caused by accelerated muscle protein depletion related to aging, disease, and dialysis.[16] PEW is characterized by reduced body protein and energy stores, which is a result of inadequate diet, inflammation, oxidative stress, acidosis, nutrient loss to dialysate, altered response to anabolic hormones, increased uremic toxins, and blood loss in patients with CKD.[17] Severe PEW is associated with increased mortality risk that necessitates preventive measures.[18] Sarcopenia is also common among older people and poses a risk for patients undergoing dialysis irrespective of age.[19] Sarcopenia, characterized by progressive and systemic loss of muscle mass and strength,[20] is diagnosed as severe when accompanied by reduced muscle function.[21] A systematic review and meta-analysis indicated that the prevalence of severe sarcopenia is significantly higher in patients undergoing dialysis.[22] Therefore, patients with CKD face multiple risk factors related to tongue pressure, including aging, nutritional disorders, and sarcopenia. However, studies on tongue pressure in patients with renal failure remain limited. Kamijo et al.[23] reported that age and grip strength are independent factors influencing tongue pressure in patients undergoing peritoneal dialysis (PD) owing to the lack of reports on tongue function and oral frailty in internal medicine. RRT includes hemodialysis (HD), PD, and kidney transplantation, each with unique advantages and disadvantages. Patients undergoing HD and PD have different physical function and energy levels based on the 36-Item Short Form Health Survey.[24] Moreover, given that relatively few dialysis patients can be maintained on PD, the number of patients undergoing HD far outnumbers PD patients.[14] Therefore, there is a significant need for a separate investigation into tongue function in patients undergoing HD.

This study aimed to investigate tongue pressure in outpatients undergoing maintenance HD (MHD) and identify factors associated with tongue pressure, such as nutritional status and components of sarcopenia. The confirmed related factors can serve as indicators for treating decreased tongue pressure in patients undergoing MHD. Furthermore, because not all dialysis clinics are currently equipped with tongue pressure measurement devices, there are several clinics where direct measurement of tongue pressure remains challenging. In such clinics, the use of related factors may assist in identifying patients with decreased tongue pressure.

MATERIALS AND METHODS

Design and Participants

This study was approved by the Institutional Ethics Committee of Watanabe Clinic, Kakiokai Medical Corporation (Approval number 241191), and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all subjects involved in the study. This cross-sectional study included patients who attended our clinic for MHD between February and August 2024 and consented to participate in the study. The following exclusion criteria were used: (1) cognitive impairment or consciousness disorders hindering the ability to understand the test methods, (2) inability to undergo bioelectrical impedance analysis (BIA) because of body movements or other medical devices, (3) missing data, and (4) lack of consent.

Measures

Primary and Secondary Outcome Measures

The primary endpoint was the evaluation of tongue pressure in outpatients undergoing MHD. Minakuchi et al.[25] identified seven conditions (poor oral hygiene, dry mouth, reduced occlusal force, reduced tongue and lip motor function, decreased tongue pressure, reduced masticatory function, and impaired swallowing function) for diagnosing oral hypofunction, with a maximum tongue pressure less than 30 kPa indicating reduced tongue pressure. Therefore, participants were divided into two groups based on tongue pressure: low tongue pressure (<30 kPa) and high tongue pressure (≥30 kPa). Tongue pressure was measured using a tongue pressure measurement device (TPM-01, JMS, Hiroshima, Japan). With the patient in a seated position, a balloon-type probe was inserted into the oral cavity, and the probe was pressed against the palate with the tongue for approximately 7 s. Measurements were taken three times, and the average was recorded. Clinical information, nutritional indicators, and physical function were also evaluated for their association with tongue pressure.

Clinical Information

The clinical information of the participants included age, sex, height, current weight (dry weight), body mass index (BMI), dialysis duration, history of aspiration pneumonia and cerebrovascular disease, skeletal muscle mass index (SMI), and phase angle (PhA). Predialysis blood test items included albumin, total cholesterol, creatinine, C-reactive protein (CRP), and phosphorus levels. History of cerebrovascular disease, including stroke, cerebral hemorrhage, and subarachnoid hemorrhage, was extracted from medical records. SMI, calculated as the sum of the limb skeletal muscle mass divided by height squared,[26] was measured using a body composition analyzer (InBody BWA, InBody, Tokyo, Japan) by BIA. PhA, derived from resistance (R) and reactance (Xc) as PhA (°) = −arctangent (Xc/R) × (180/π),[27] was measured using the same device.

Nutritional Indicators

Nutritional assessment tools included the geriatric nutritional risk index (GNRI)[28] and the nutritional risk index for Japanese hemodialysis patients (NRI-JH).[29] The GNRI was calculated as GNRI = 14.89 × albumin (g/dL) + 41.7 × (current weight/ideal weight), with ideal weight defined as height squared (m^2) × 22.[28] If the current weight exceeded the ideal weight, the ratio was set to 1. The GNRI was classified into groups requiring nutritional support (<92) and not requiring nutritional support (≥92).[30] NRI-JH, based on albumin, total cholesterol, creatinine, and BMI, classified patients into low-risk (0–7 points), medium-risk (8–10 points), and high-risk (≥11 points) groups.[29] In this study, patients were categorized into low-risk (0–7 points) and medium/high-risk (8–13 points) groups.

Grip Strength

Grip strength was measured using a Smedley-type dynamometer (Matsumiya Medical Equipment Manufacturing, Tokyo, Japan). During the measurement, ambulatory patients were standing, whereas users in wheelchairs were seated, and the grip strength was measured bilaterally using the maximum value. For patients with hemiplegia caused by cerebrovascular disease, only the unaffected side was evaluated.

Physical Function

Physical function was assessed by measuring the gait speed or the five-repetition sit-to-stand test. Gait speed was calculated by the time taken to walk a 6-m straight path at a normal pace (m/s). Patients with visual impairment or walking difficulty performed the five-repetition sit-to-stand test. This test utilized a chair with a backrest and a seat height of 40 cm. Participants were instructed to stand up and sit down five times as quickly as possible. The duration from the start signal to the fifth stand was recorded once.

Diagnosis of Sarcopenia

Sarcopenia was diagnosed based on muscle mass, muscle strength, and physical function. According to the Asian Working Group for Sarcopenia criteria,[31] low muscle strength was defined as grip strength less than 28 kg for men and less than 18 kg for women, low physical function was defined as walking speed less than 1 m/s or a sit-to-stand test time of 12 s or longer, and low muscle mass was defined as SMI less than 7.0 kg/m^2 for men and less than 5.7 kg/m^2 for women. Sarcopenia was diagnosed based on the presence of low muscle mass combined with low muscle strength or low physical function. Patients who were unable to walk independently because of motor paralysis or ataxia were considered to have low physical function.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation if data were normally distributed, whereas non-normally distributed data were expressed as median [interquartile range]. The normality of each variable was verified using the Shapiro–Wilk test. Fisher's exact test was used for comparisons of patient background between the two groups or the chi-squared test for categorical variables. For continuous variables, Student's *t*-test or Welch's test was applied if data were normally distributed, and the Mann–Whitney U test was used for non-normally distributed data. Age-wise comparisons of tongue pressure were performed using the one-way analysis of variance with Tukey's multiple-comparison correction after confirming normality. Correlations between variables were analyzed using Pearson's correlation coefficient (r) for normally distributed data and Spearman's rank correlation coefficient (ρ) for non-normally distributed data. Multiple regression analysis (stepwise method) was performed to identify factors associated with tongue pressure in patients undergoing dialysis. Analyses included models using the GNRI and NRI-JH as representative nutritional indices. Model A included age, sex, history of cerebrovascular disease, GNRI, SMI, PhA, and grip strength as independent variables, whereas model B replaced the GNRI with NRI-JH. The normality of the dependent variable and homoscedasticity and normality of the residuals were confirmed in multiple regression analysis. The variance inflation factor (VIF) was computed to ensure the absence of multicollinearity among independent variables. Adjusted R^2 was calculated to evaluate the goodness of fit. Statistical analyses were performed using EZR version 1.65,[32] with the level of significance set at <5%.

Table 1. General characteristics of the study group stratified by tongue pressure

Characteristic	Total patients (n=80)	Tongue pressure group <30 kPa (n=47)	Tongue pressure group ≥30 kPa (n=33)	P value
Age, years	81.0 [71.0, 86.0]	84.0 [74.5, 87.0]	74.0 [68.0, 82.0]	0.005
Female	29 (36.2)	22 (46.8)	7 (21.2)	0.033
Aspiration pneumonia	8 (10.0)	5 (10.6)	3 (9.1)	1.000
Hemodialysis duration, months	44.5 [15.5, 91.0]	51.0 [19.0, 91.5]	37.0 [9.0, 74.0]	0.213
Cerebrovascular disease	16 (20.0)	13 (27.7)	3 (9.1)	0.050
BMI, kg/m^2	19.9 [17.6, 22.3]	18.5 [17.2, 21.0]	21.0 [19.2, 24.2]	0.005
Hemoglobin, g/dL	11.3 ± 1.2	11.3 ± 1.2	11.4±1.2	0.743
Albumin, g/dL	3.5 [3.2, 3.8]	3.4 [3.1, 3.8]	3.6 [3.4, 3.9]	0.017
Creatinine, mg/dL	8.7 ± 2.3	8.1 ± 2.3	9.4 ± 2.3	0.016
CRP, mg/L	0.19 [0.08, 0.52]	0.20 [0.07, 0.52]	0.13 [0.08, 0.50]	0.750
Phosphorus, mg/dL	4.9 [4.1, 5.5]	4.7 [4.0, 5.5]	5.1 [4.3, 5.9]	0.133
Total cholesterol, mg/dL	146.5 [124.8, 168.3]	144.0 [123.5, 167.5]	150.0 [127.0, 169.0]	0.642
GNRI score	90.0 [83.0, 94.3]	88.0 [80.0, 94.0]	92.0 [89.0, 98.0]	0.004
NRI-JH score	7.0 [3.0, 8.0]	7.0 [4.0, 8.5]	4.0 [3.0, 7.0]	0.038
SMI, kg/m^2	5.5 ± 1.2	5.1 ± 1.1	6.1 ± 1.2	<0.001
PhA, degrees	3.9 ± 1.0	3.6 ± 0.9	4.3 ± 1.1	0.001
Handgrip strength, kg	17.4 ± 8.9	13.7 ± 6.7	22.5 ± 9.3	<0.001
Low muscle mass	64 (80.0)	43 (91.5)	21 (63.6)	0.004
Low muscle strength	61 (76.2)	40 (85.1)	21 (63.6)	0.034
Low physical performance	49 (61.3)	34 (72.3)	15 (45.5)	0.020
Sarcopenia	55 (68.8)	37 (78.7)	18 (54.5)	0.028
Tongue pressure, kPa	29.0 ± 9.1	22.5 ± 4.7	38.3 ± 5.3	<0.001

Data given as median [interquartile range], number (%), or mean ± standard deviation.

RESULTS

Patient Background

During the study period, 105 patients were undergoing MHD at our clinic. Twenty-five patients were excluded: 12 patients had cognitive or consciousness impairments that made understanding the test methods difficult; BIA could not be performed for 7 patients; 5 patients had incomplete data; and 1 patient did not consent to the tests. The analysis included the remaining 80 patients.

Patient data are shown in **Table 1**. The trend of age-specific tongue pressure is displayed in **Fig. 1,** and the prevalence of sarcopenia across age groups is shown in **Fig. 2**. The median age of the patients was 81.0 years, and histories of aspiration pneumonia and cerebrovascular disorders were observed in 8 (10.0%) and 16 (20.0%) patients, respectively. Nutritional indices showed a median NRI-JH of 7.0 points and a GNRI of 90.0. Sarcopenia was observed in 55 out of 80 (68.8%) patients, with a significantly higher prevalence in the group aged 85 years and older than in those aged 64 years and older and in those aged 65–74 years. The mean tongue pressure was 29.0 kPa, and the Shapiro–Wilk test indicated that the tongue pressure (P=0.222) was normally distributed. Forty-seven patients (58.8%) had a tongue pressure less than 30 kPa. Comparisons between the low tongue pressure group (<30 kPa) and the high tongue pressure group (>30 kPa) showed significant differences in age, sex, BMI, albumin, creatinine, GNRI, NRI-JH, SMI, PhA, handgrip strength, skeletal muscle mass, muscle strength, physical function, and sarcopenia. Tongue pressure was significantly lower in the group aged 85 years and older than in those aged up to 64 years and those aged 65–74 years.

Correlations between Tongue Pressure and Variables

Table 2 presents the results of the correlation analysis between tongue pressure and various factors. Moderate positive correlations were observed with albumin (ρ=0.415,

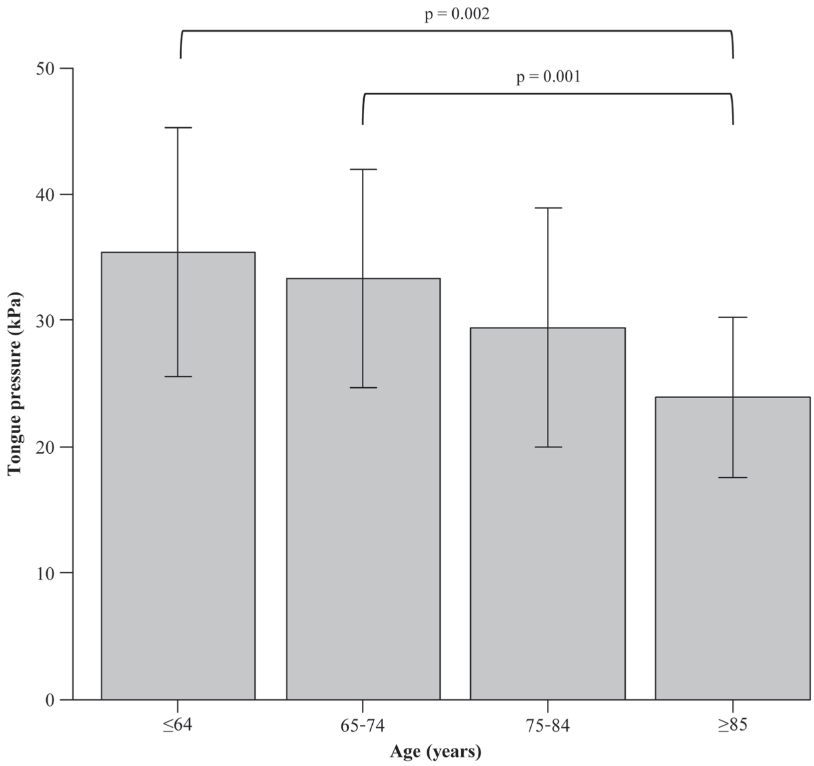

Fig. 1. Comparison of mean tongue pressure between age groups. Tongue pressure was compared using one-way analysis of variance, and a post-hoc test was performed using Tukey's honestly significant difference test. Error bars represent standard deviation.

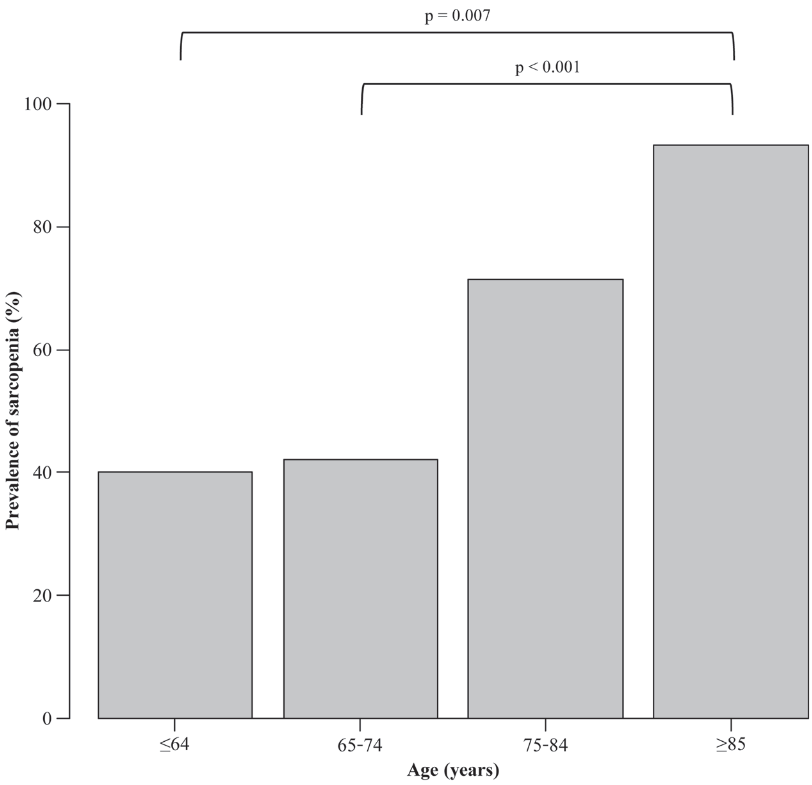

Fig. 2. Comparison of sarcopenia prevalence between age groups (Fisher's exact test).

Table 2. Correlations between tongue pressure and variables

Variable	Correlation coefficient	P value
Age	−0.486	<0.001
Hemodialysis duration	−0.139	0.219
BMI	0.360	<0.001
Hemoglobin	−0.035	0.758
Albumin	0.415	<0.001
Creatinine	0.390	<0.001
CRP	−0.097	0.392
Phosphorus	0.223	0.047
Total cholesterol	0.189	0.093
GNRI score	0.442	<0.001
NRI-JH score	−0.351	0.001
SMI	0.509	<0.001
PhA	0.425	<0.001
Handgrip strength	0.514	<0.001

Correlation coefficient was measured as Spearman's rank correlation coefficient (ρ) or Pearson's correlation coefficient (r).

P <0.001), SMI (r=0.509, P <0.001), PhA (r=0.425, P <0.001), and handgrip strength (ρ=0.514, P <0.001). Age (ρ=−0.486, P <0.001) showed a moderately negative correlation with tongue pressure. Among nutritional indicators, the GNRI (ρ=0.442, P <0.001) demonstrated a moderate positive correlation, whereas the NRI-JH (ρ=−0.351, P=0.001) exhibited a weak negative correlation.

Multivariable Analyses for Tongue Pressure

The results of the stepwise multiple regression analysis, with tongue pressure as the dependent variable, are shown in **Table 3**. In model A, the GNRI was included as an independent nutritional variable. The stepwise method utilized age, cerebrovascular disease, GNRI, and grip strength as independent variables and incorporated them into the regression model. Model A revealed that the GNRI (β=0.252, P=0.013), age (β=−0.255, P=0.009), and grip strength (β=0.294, P=0.005) had significant effects on tongue pressure. In model B, the NRI-JH was included as an independent nutritional variable. In the stepwise method, age, cerebrovascular disease, NRI-JH, and grip strength were selected as independent variables for the regression model. Model B indicated that age (β=−0.265, P=0.008) and grip strength (β=0.341, P=0.001) were significantly and independently associated with tongue pressure. Adjusted R^2 values for models A and B were 0.396 and 0.369, respectively, and all VIF values for the independent variables were less than 5.

DISCUSSION

Given that tongue pressure reflects clinical signs of tongue movements and coughing in dysphagia,[33] tongue pressure should be measured to assess the strength of swallowing muscles.[5] Adams et al.[34] reported that about half of the studies on tongue pressure involved healthy adults, whereas very few studies examined populations with conditions such as Parkinson's disease, head and neck cancer, traumatic brain injury, oculopharyngeal muscular dystrophy, or cerebrovascular accident. Despite reports on various disease groups, studies on patients undergoing dialysis are still limited.

Table 3. Multivariate analysis results for tongue pressure

	β	95% CI	SE	t	P value
Model A					
Age	−0.255	−0.445, −0.066	0.095	−2.688	0.009
Cerebrovascular disease	−0.404	−0.843, 0.035	0.220	−1.832	0.071
GNRI score	0.252	0.054, 0.450	0.100	2.534	0.013
Handgrip strength	0.294	0.093, 0.495	0.101	2.915	0.005
Adjusted R^2=0.396					
Model B					
Age	−0.265	−0.459, −0.070	0.098	−2.713	0.008
Cerebrovascular disease	−0.448	−0.902, 0.005	0.228	−1.970	0.053
NRI-JH score	−0.171	−0.367, 0.026	0.099	−1.732	0.087
Handgrip strength	0.341	0.142, 0.539	0.100	3.422	0.001
Adjusted R^2=0.369					

β, standardized partial regression coefficient; CI, confidence interval; SE, standard error; t, t-statistic.

In the present study, we identified the factors associated with tongue pressure in patients undergoing MHD, including older outpatients. The mean tongue pressure was 29.0 kPa. Tongue pressure was significantly correlated with albumin, GNRI, and NRI-JH, as well as with SMI and grip strength. Moreover, age, grip strength, and GNRI were independently associated with tongue pressure in the HD group. Reportedly, age, grip strength, and malnutrition as assessed by GNRI in patients with MHD, may indicate the possibility of decreased tongue pressure. To the best of our knowledge, this is the first study to clarify the relationship between tongue pressure and GNRI and NRI-JH in patients undergoing MHD.

In healthy adults, tongue strength decreases with age, and older adults have average tongue pressures that are 10–15 kPa lower than younger adults.[34] Regarding the age at which tongue pressure declines, Hara et al.[11] reported that tongue pressure in healthy adults significantly decreases in men in their 60s and in women in their 50s. Arakawa et al.[35] also demonstrated that healthy individuals younger than 60 years of age have significantly higher tongue pressure than those aged over 60 years. Kamijo et al.[23] found that age is an independent factor that affects tongue pressure in patients undergoing PD. In the present study of outpatients undergoing MHD, tongue pressure was significantly lower in the oldest group (aged ≥85 years) than in the younger age groups (≤64 years and 65–74 years). Multivariate analysis showed that age was significantly and independently associated with tongue pressure. Therefore, age-related decline in tongue pressure observed in healthy adults also applies to patients undergoing HD. Nicosia et al.[9] suggested that the age-related decline in tongue strength may be caused by increased amyloid deposition in the tongue muscles,[36] similar to changes reported in limb muscles.

Sarcopenia is closely related to tongue muscle weakness through aging,[10] and both aging and sarcopenia adversely affect swallowing muscles.[37] Older patients with sarcopenia have significantly lower tongue pressure than patients without sarcopenia, and tongue pressure positively correlated with sarcopenia subcomponents. Machida et al.[37] showed that whole-body sarcopenia was independently associated with tongue pressure in community-dwelling older individuals of both sexes. In addition, a study of older inpatients at rehabilitation hospitals reported that tongue pressure was independently associated with handgrip strength.[12] Sarcopenia was found to be clinically significant in patients undergoing dialysis and was associated with increased mortality risk.[38] A study of patients undergoing dialysis also reported significantly lower tongue pressure in patients with sarcopenia undergoing PD.[23] Similarly, in the present study, tongue pressure in outpatients undergoing MHD was significantly lower in those with sarcopenia, with significant positive correlations between tongue pressure and SMI and handgrip strength. Furthermore, handgrip strength was independently associated with tongue pressure. Although the mechanisms underlying lower tongue pressure in patients with sarcopenia are not well understood, sarcopenia is a systemic disease that affects skeletal muscles throughout the body, and the decline in tongue strength may mirror the effect on limb muscles.[4] This association between sarcopenia and tongue pressure is deemed consistent in patients undergoing MHD.

Malnutrition is considered a late complication of chronic renal failure, and in patients undergoing dialysis, malnutrition may begin as early as stage IV of chronic renal failure.[39] However, given that no single method can comprehensively and accurately assess the nutritional status of patients undergoing dialysis, evaluations must include a panel of anthropometric and biochemical measurements correlated with nutritional status.[39] In this study, the GNRI and NRI-JH were selected as clinical tools for screening nutritional status, and their relationships with tongue pressure were examined. The GNRI is calculated using a simple formula based on three nutritional variables: serum albumin, height, and weight. It correlates highly with the malnutrition–inflammation score and accurately identifies malnutrition in patients undergoing MHD.[40] Conversely, NRI-JH is a nutritional risk index for patients undergoing HD, is based on BMI, serum creatinine, albumin, and total cholesterol levels, and is related to the risk of death within 1 year.[29] For comparison, the GNRI comprises serum albumin level, current weight, and ideal weight, not including muscle mass assessment, whereas NRI-JH includes muscle mass evaluation reflected by serum creatinine level.[41] In studies on the relationship between nutritional status and tongue pressure in community-dwelling older people, a positive correlation was found between tongue pressure and the Mini Nutritional Assessment (MNA) score, indicating a link between decreased tongue pressure and increased malnutrition risk.[3] Studies on older inpatients at rehabilitation hospitals also showed an independent association between tongue pressure and MNA-short form.[12] In addition, studies on healthy populations[7,8] and older people in nursing homes[33] have shown significant positive correlations between BMI and tongue pressure. Malnutrition is common in patients with end-stage kidney disease, often accompanied by PEW.[41] In studies on patients undergoing dialysis, a significant correlation was found between tongue pressure and nutritional indicators such as albumin, prealbumin, and

BMI.[23] Our findings show significant correlations between tongue pressure and albumin level, BMI, GNRI, and NRI-JH in patients undergoing MHD, and multivariate analysis indicates that the GNRI is significantly and independently associated with tongue pressure. This finding suggests a relationship between nutritional status and tongue pressure in patients undergoing MHD. Therefore, malnutrition in patients undergoing MHD may reduce tongue pressure. Consequently, appropriate and sufficient nutritional management may reduce the risk of decreased tongue pressure in these patients. Sommer et al.[8] noted that the positive correlation between BMI and tongue pressure must be interpreted considering that most participants were not obese. Hara et al.[7] also reported a correlation between BMI and tongue pressure in healthy adults and older groups without obesity. Our finding that BMI positively correlated with tongue pressure in most of the patients undergoing MHD who were not obese is consistent with these reports. In this study, the GNRI correlated with tongue pressure in patients undergoing MDH, and multivariate analysis revealed a significant and independent association. The GNRI is calculated based on serum albumin level and BMI,[42] and both factors were observed to be related to tongue pressure. Therefore, it is reasonable to expect that combination of these parameters in the GNRI will show significant correlation with tongue pressure. Conversely, although NRI-JH showed a significant correlation with tongue pressure in patients undergoing MHD, no correlation was found in the multivariate analysis. NRI-JH is calculated using BMI, serum albumin, serum creatinine, and total cholesterol levels. In this study, a weak positive correlation was observed between serum creatinine and tongue pressure; however, no significant correlation was found between total cholesterol level and tongue pressure, which might explain the lack of a significant effect of NRI-JH on tongue pressure. Therefore, the GNRI may be more important than NRI-JH in predicting tongue pressure in patients undergoing MHD. Malnutrition has been identified as one of the late-stage complications of chronic renal failure.[39] However, in this study, no significant difference was observed in the dialysis duration between the group with tongue pressure below 30 kPa and that with tongue pressure above 30 kPa. Kurajoh et al.[41] reported that there was no significant difference in the dialysis duration between low-risk and medium/high-risk states based on the NRI-JH score in a study involving Asian patients undergoing MHD. Although malnutrition is a complication of end-stage renal failure, nutritional therapy for dialysis patients may mitigate nutritional disorders, which may not necessarily be influenced by the dialysis duration. This reasoning may explain the lack of significant difference between the groups in this study. Further research is warranted to elucidate this point.

This study has several limitations. First, because our study is cross-sectional in nature, the temporal sequence for confirming the cause-and-effect associations is unclear; therefore, the findings are limited to the identification of associations. Future studies utilizing longitudinal or interventional designs will be required. Second, a single-center design and small sample size may limit the generalizability of the results. Therefore, multicenter studies are needed to validate our findings. Third, participants were not stratified by sex, and physiological differences between sexes were not reflected in the data, potentially overlooking sex-specific differences. In addition, there were fewer female participants, possibly introducing selection bias. Fourth, potential confounders such as the number and condition of teeth, chewing ability, and medication use were not included in the statistical analysis. Future studies should address these factors. Finally, cognitive function was only assessed by verbal confirmation of the ability to understand the test methods, without validated tests. Therefore, future investigations should employ objective assessment scales to evaluate cognitive function.

CONCLUSION

The results of this study indicate that age, albumin level, creatinine level, SMI, handgrip strength, GNRI score, and NRI-JH score are associated with tongue pressure in patients undergoing maintenance hemodialysis. Multivariate analysis indicated that age, handgrip strength, and GNRI score are independently associated with tongue pressure. Therefore, nutritional indices using age, handgrip strength, and GNRI may be used as indicators of tongue pressure in patients undergoing MHD.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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