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Differences in maximum phonation time based on body mass index in chronic heart failure patients

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Maximum phonation time (MPT) is widely used to evaluate maximum vocal capabilities because it is quick, non-invasive, and inexpensive [1]. A previous study suggested showed a positive correlation between MPT and poor outcome in relation to indices of exercise capacity such as peak oxygen uptake, and there are differences in MPT in relation to an exercise capacity threshold of ≥ 5 metabolic equivalents (METs) in chronic heart failure (CHF) outpatients [2]. In addition, an exercise capacity of ≥ 5 METs extracted a cutoff value for MPT of 18.27 seconds [2].

Another report showed that low body mass index (BMI) is also associated with a poor outcome in CHF, and survival can be further impaired if CHF progresses to cardiac cachexia [3]. This report also suggested that biomarkers such as adiponectin and N-terminal pro-B-type natriuretic peptide are typically increased in patients with CHF [3]. Little is known about the relation between MPT and BMI in CHF patients. We hypothesized that MPT might be related to BMI and that there could be differences in the MPT of CHF patients across different levels of BMI (i.e., low, normal, and high BMI). Therefore, the purpose of the present study was to determine 1) the relation between MPT and BMI in CHF patients and 2) differences in the MPT of these patients in relation to BMI.

In this cross-sectional study, 118 consecutive patients aged from 30 to 80 years old with CHF who visited the St. Marianna University School of Medicine Hospital as outpatients were selected for evaluation of MPT. We excluded patients with neurological, peripheral vascular, orthopedic, and pulmonary disease, and those classified as New York Heart Association (NYHA) functional class IV.

Patient characteristics including age, sex, BMI, left ventricular ejection fraction, brain natriuretic peptide (BNP) concentration, NYHA functional class etiology of heart failure, and medications were evaluated by review of the patients' medical records. A cardiologist used echocardiography to assess left ventricular ejection fraction as the index of cardiac function.

The St. Marianna University School of Medicine Institutional Committee on Human Research approved this study, and informed consent was obtained from each patient.

MPT was measured with a stopwatch with the patient in the seated position. Patients were asked to produce a sustained vowel /a:/ sound for as long as possible and were verbally encouraged during this effort. The method, variability, and reliability of this measurement have been described previously [1,2]. All trials were assessed by a physical therapist. Three consecutive trials were allowed with a 15-second break between each trial. The highest value measured was considered the MPT (sec) in this study.

BMI, calculated as $\text{mass (kg)} / (\text{height (m)})^2$, is a well-established method of evaluating body weight. We classified the patients into one of three BMI groups according to the World Health Organization report [4]: BMI < 18.50 kg/m², low BMI group; BMI from 18.50 to 24.99 kg/m²; normal BMI group; and BMI from 25.00 to 29.99 kg/m² and ≥ 30.00 kg/m² (considered to indicate overweight or obesity, respectively), high BMI group [4,5].

Results are expressed as mean $\pm$ standard deviation (SD). Simple Pearson's correlation analyses were used to test relations between the variables of BMI and MPT. To compare MPT between the three groups, one-way analysis of covariance (ANCOVA) was performed with the variables as covariates if there were any differences in clinical characteristics. The unpaired *t*-test and χ^2 test were used to test for differences in clinical characteristics and MPT values in the three BMI groups. A *p* value of < 0.05 was considered to indicate statistical significance. Statistical analyses were performed with IBM SPSS 17.0 J statistical software (IBM SPSS Japan, Inc., Tokyo, Japan).

The 118 patients were divided into three groups based on their BMI: low BMI group (*n* = 20), normal BMI group (*n* = 61), and high BMI group (*n* = 37). Patient characteristics except for age, BMI, and BNP were similar, whereas differences in NYHA functional class tended to be significant between the three groups (Table 1). MPT correlated positively with BMI in all

patients ($r = -0.45$, $p < .001$). A scatter plot showing the relations between BMI and MPT results for all CHF patients is presented in Figure 1. After ANCOVA analysis using age, BNP, and NYHA functional class as the covariates, the MPT values for the three BMI groups were found to be significantly different (Table 1, Figure 2).

In the present study, BMI correlated positively with MPT in all patients, and MPT values in the low BMI group were found to be significant different compared with those in the normal and high BMI groups. A previous study of healthy young women suggested that MPT in the underweight subjects was significantly different from that in the normal-weight and obese subjects [5]. Although there were several differences, such as age (from 18.8 to 24.5 yrs.), sex (females only), and clinical characteristics (healthy subjects), between their study and ours, the results of our study were similar to and supported the results of Barsties et al. [5]. Thus, BMI might adequately reflect the effective value of MPT in CHF patients. However, the relations between MPT and age and sex-related differences and other factors such as differences in disease severity in CHF patients were not evaluated in the present study. Thus, these factors should be evaluated in future longitudinal settings in CHF patients.

We previously showed that receiver-operating characteristic curve analysis of exercise capacity of ≥ 5 metabolic equivalents in relation to mortality and activity of daily living extracted a cutoff value for MPT of 18.27 sec [2]. The average MPT values in the low BMI group (95% CI, 12.4 to 17.9 sec) were lower than this cutoff value [2]. Thus, it may be important to understand how low BMI influences not only poor outcomes related to survival and health-related quality of life but also low MPT values in CHF patients before exercises can be designed to improve MPT in these patients.

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127 **Figure Legends**

128 **Fig. 1.** Scatter plot shows the relation between body mass index (BMI) and maximum
129 phonation time results for all chronic heart failure patients. Maximum phonation time
130 correlated positively with BMI in all patients ($r = -0.45, p < .001$).

131

132 **Fig. 2.** Maximum phonation time values obtained in the three body mass index (BMI) groups
133 were significantly different. *After post hoc analysis, differences between the low BMI group
134 and both the normal and high BMI groups were significant ($p < .001$).

135

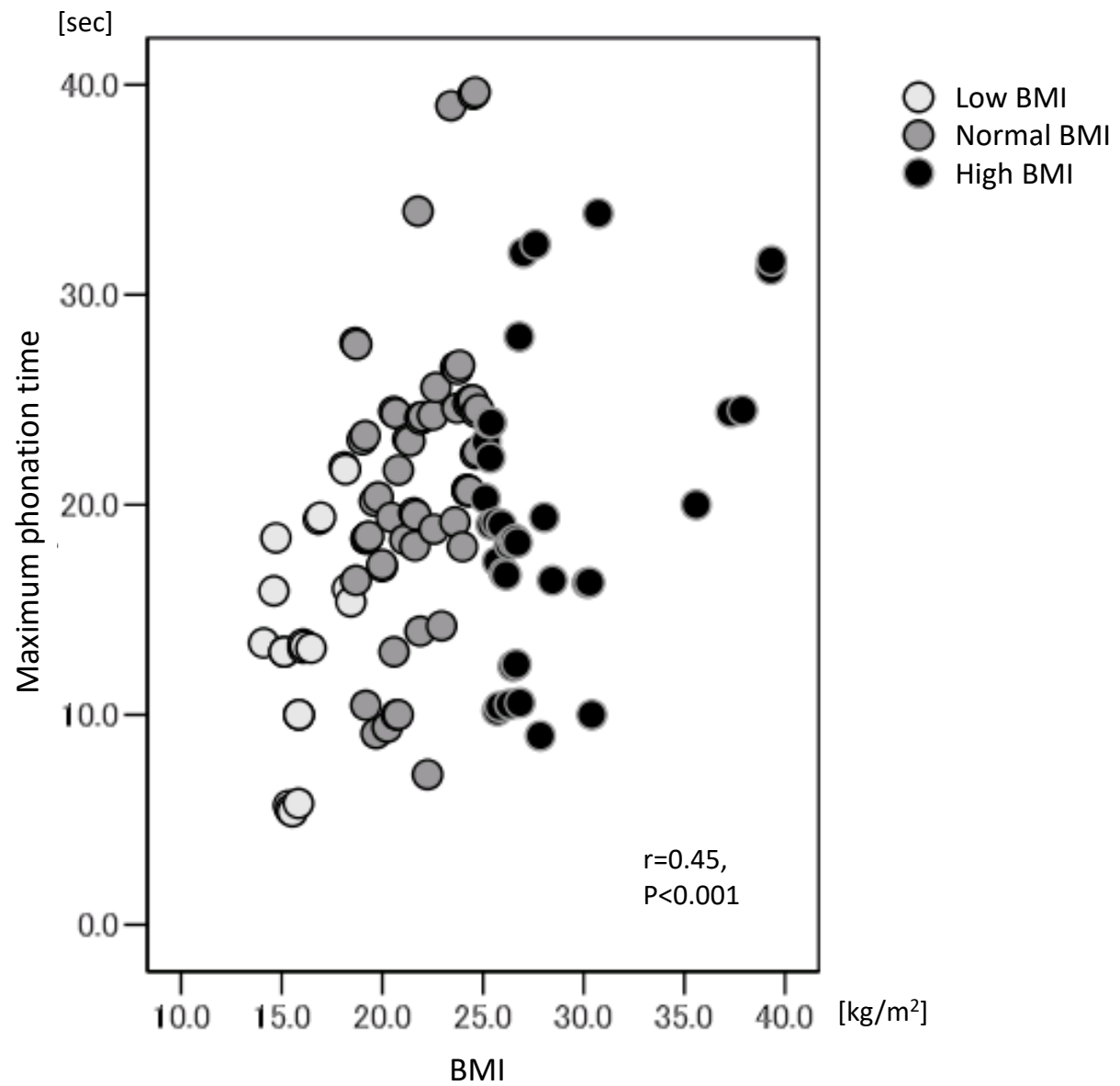


Fig. 1.

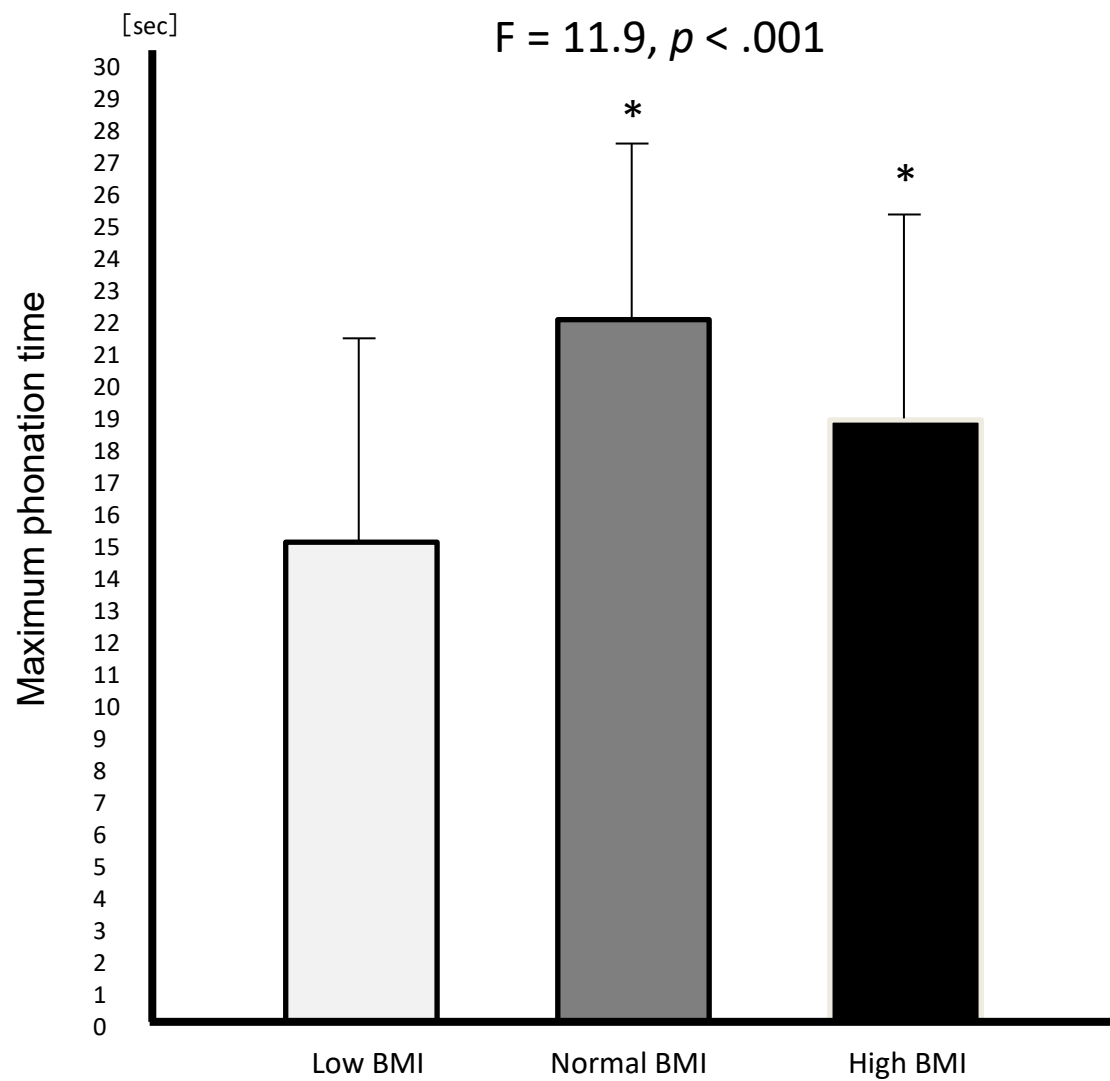


Fig. 2.

Table 1

Clinical characteristics of the patients.

Characteristic	Low BMI	Normal BMI	High BMI	<i>F</i> or χ^2 value	<i>P</i> value
No. of patients	20	61	37		
Age (yrs)	60.9 ± 11.1	56.7 ± 8.5	48.6 ± 9.9	13.3*	<0.001
Male (%)	90.0	86.6	80.5	1.09	0.58
BMI (kg/m ²)	16.0 ± 1.1	21.8 ± 2.1	28.3 ± 4.1	137.6*	<0.001
LVEF (%)	35.4 ± 7.9	33.0 ± 12.1	32.3 ± 12.4	0.46*	0.63
BNP (pg/ml)	383.3 ± 265.6	255.1 ± 182.5	199.9 ± 144.1	5.76*	0.004
NYHA class (I/II/III)	0/16/4	19/34/8	11/20/6	8.38	0.078
Etiology (%)					
Cardiomyopathy	55.0	42.6	54.0	2.79	0.83
Previous MI	20.0	22.9	24.3		
Arrhythmia	15.0	21.2	16.2		
CABG/VR	10.0	13.1	5.5		
Medications (%)					
Beta-blockers	86.6	80.7	88.4	3.40	0.18
ARB	43.3	44.3	40.5	0.45	0.79
ACEI	53.3	50.3	55.8	0.92	0.63
Diuretic	83.3	81.2	85.1	0.76	0.68
Maximum phonation time (sec)**	15.2 ± 6.2 (12.4-17.9)	21.5 ± 5.9 ^{\$} (19.8-23.0)	19.1 ± 6.3 [#] (16.9-21.3)	11.9	<0.001

ACEI–angiotensin converting enzyme inhibitor; ARB–angiotensin receptor blocker; BMI–body mass index; BNP–brain natriuretic peptide; CABG/VR–coronary artery bypass grafting/valve replacement; LVEF–left ventricular ejection fraction; MI–myocardial infarction; NYHA–New York Heart Association.

* *F* value.

** Maximum phonation time is shown as mean $\pm$ standard deviation (95% confidence interval).

Independent variables of analysis of covariance: age, BNP and NYHA.

^s vs. significant differences for high BMI.

[#] vs. significant differences for high BMI.