Sarcopenia is not associated with inspiratory muscle strength but with expiratory muscle strength among older adults requiring long-term care/support

Yohei Sawaya [Corresp., Equal first author, 1, 2], **Takahiro Shiba** [Equal first author, 2], **Masahiro Ishizaka** [1], **Tamaki Hirose** [1, 2], **Ryo Sato** [2], **Akira Kubo** [1], **Tomohiko Urano** [Corresp. 2, 3]

[1] Department of Physical Therapy, School of Health Sciences, International University of Health and Welfare, Otawara, Tochigi, Japan

[2] Nishinasuno General Home Care Center, Department of Day Rehabilitation, Care Facility for the Elderly "Maronie-en", Nasushiobara, Tochigi, Japan

[3] Department of Geriatric Medicine, School of Medicine, International University of Health and Welfare, Narita, Chiba, Japan

Corresponding Authors: Yohei Sawaya, Tomohiko Urano
Email address: sawaya@iuhw.ac.jp, turano@iuhw.ac.jp

Background. Recently, the concept of respiratory sarcopenia has been advocated, but evidence is lacking regarding which respiratory parameters are appropriate indicators. Therefore, we investigated the association between sarcopenia, respiratory function, and respiratory muscle strength to identify the most appropriate parameters for respiratory sarcopenia. **Methods.** We included 124 older adults (67 men, 57 women; average age 77.2 ± 8.3 years) requiring long-term care/support who underwent Day Care for rehabilitation. Handgrip strength, usual gait speed, and skeletal muscle mass were measured using bioelectrical impedance analysis. Participants were then diagnosed with sarcopenia using the algorithm of the Asian Working Group for Sarcopenia 2019. Parameters of respiratory function (forced vital capacity, forced expiratory volume in one second [FEV1.0], FEV1.0%, and peak expiratory flow rate) and respiratory muscle strength (maximal expiratory pressure [MEP] and maximal inspiratory pressure) were also measured according to American Thoracic Society guidelines. Respiratory parameters significantly related to sarcopenia were identified using binomial logistic regression and receiver operating characteristic analyses. **Results.** Seventy-seven participants were classified as having sarcopenia. Binomial logistic regression analysis showed that MEP was the only respiratory parameter significantly associated with sarcopenia. The cut-off MEP value for predicting sarcopenia was 47.0 cmH_2O for men and 40.9 cmH_2O for women.

Conclusions. The most appropriate parameter for assessing respiratory sarcopenia may be MEP, which is an indicator of expiratory muscle strength , rather than FVC, MIP, or PEFR, as suggested in previous studies . Measuring MEP is simpler than measuring respiratory function parameters. Moreover, it is expected to have clinical applications such as respiratory sarcopenia screening .

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5 Yohei Sawaya,[Equal first author,1,2*], Takahiro Shiba,[Equal first author,2], Masahiro Ishizaka[1], Tamaki

6 Hirose[1,2], Ryo Sato[2], Akira Kubo[1], and Tomohiko Urano[2,3*]

8 [1] Department of Physical Therapy, School of Health Sciences, International University of Health
9 and Welfare, Tochigi, Japan
10 [2] Nishinasuno General Home Care Center, Department of Day Rehabilitation, Care Facility for
11 the Elderly "Maronie-en," Tochigi, Japan
12 [3] Department of Geriatric Medicine, School of Medicine, International University of Health and
13 Welfare, Chiba, Japan

15 ***Corresponding author**
16 Tomohiko Urano, MD, PhD
17 Department of Geriatric Medicine, School of Medicine, International University of Health and
18 Welfare: 4-3 Kozunomori, Narita city, Chiba, 286-8686, Japan
19 Email: turano@iuhw.ac.jp
20 TEL: +81-287-36-6622
21 FAX: +81-287-36-8510

22

23 Yohei Sawaya, RPT, PhD
24 Department of Physical Therapy, School of Health Sciences, International University of Health
25 and Welfare: 2600-1 Kitakanemaru, Otawara city, Tochigi 324-8501, Japan
26 Email: sawaya@iuhw.ac.jp
27 TEL: +81-287-24-3018
28 Fax: +81-287-24-3100

29

30 Abstract

31 **Background.** Recently, the concept of respiratory sarcopenia has been advocated, but evidence
32 is lacking regarding which respiratory parameters are appropriate indicators. Therefore, we
33 investigated the association between sarcopenia, respiratory function, and respiratory muscle
34 strength to identify the most appropriate parameters for respiratory sarcopenia.

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36 **Methods.** We included 124 older adults (67 men, 57 women; average age 77.2 ± 8.3 years)
37 requiring long-term care/support who underwent Day Care for rehabilitation. Handgrip strength,
38 usual gait speed, and skeletal muscle mass were measured using bioelectrical impedance
39 analysis. Participants were then diagnosed with sarcopenia using the algorithm of the Asian

40   Working Group for Sarcopenia 2019. Parameters of respiratory function (forced vital capacity,
41   forced expiratory volume in one second [FEV1.0], FEV1.0%, and peak expiratory flow rate) and
42   respiratory muscle strength (maximal expiratory pressure [MEP] and maximal inspiratory
43   pressure) were also measured according to American Thoracic Society guidelines. Respiratory
44   parameters significantly related to sarcopenia were identified using binomial logistic regression
45   and receiver operating characteristic analyses.
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47   **Results.** Seventy-seven participants were classified as having sarcopenia. Binomial logistic
48   regression analysis showed that MEP was the only respiratory parameter significantly associated
49   with sarcopenia. The cut-off MEP value for predicting sarcopenia was 47.0 cmH_20 for men and
50   40.9 cmH_20 for women.
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52   **Conclusions.** The most appropriate parameter for assessing respiratory sarcopenia may be
53   MEP, which is an indicator of expiratory muscle strength, rather than FVC, MIP, or PEFR, as
54   suggested in previous studies. Measuring MEP is simpler than measuring respiratory function
55   parameters. Moreover, it is expected to have clinical applications such as respiratory sarcopenia
56   screening.
57
58   Keywords: Elderly; Respiratory muscles; Respiratory sarcopenia; Spirometry; Maximal
59   expiratory pressure
60

61   **Introduction**
62   Respiratory sarcopenia has been recently defined as "whole-body sarcopenia, and low respiratory
63   muscle mass followed by low respiratory muscle strength and/or deteriorated respiratory
64   function" (Nagano et al., 2021). However, it is difficult to assess low respiratory muscle mass as
65   no cut-off value for it has been established (Nagano et al., 2021). Therefore, criteria other than
66   respiratory muscle mass are used to diagnose respiratory sarcopenia (Nagano et al., 2021). The
67   indicators used to assess respiratory sarcopenia were maximal inspiratory pressure (MIP) and
68   forced vital capacity (FVC). However, Kera et al., who were the first to define respiratory
69   sarcopenia, used peak expiratory flow rate (PEFR) as a respiratory parameter for evaluating
70   respiratory sarcopenia (Kera et al., 2019). Several other respiratory parameters have been
71   reported to be associated with sarcopenia, but it is unclear which one is the most appropriate for
72   respiratory sarcopenia (Ohara et al., 2018; Ohara et al., 2020; Ridwan et al., 2021; Mishra et al.,
73   2020). The review also clearly stated that "there is a lack of evidence in the specificity of the
74   measures and its cut-off values" (Nagano et al., 2021). Thus, further accumulation of evidence is
75   essential.
76   Respiratory parameters are divided into those used to assess respiratory function, such as
77   FVC and PEFR, or respiratory muscle strength. Respiratory muscle strength is considered to be
78   the total muscle strength of the diaphragm and other respiratory muscles and is defined as the
79   maximal expiratory pressure (MEP) and MIP (Cook, Mead & Orzalesi, 1964). However, no

80 study has simultaneously analyzed the association between sarcopenia, respiratory function, and
81 respiratory muscle strength.
82   Regarding the respiratory muscles, the main inspiratory muscle is the diaphragm (De
83 Troyer & Estenne, 1988; Epstein, 1994). The diaphragm differs from skeletal muscles
84 considering its special embryological characteristics and its ability to continuously contract and
85 relax (Jinguji, 1978; Fujishima et al., 2019). The muscles of deglutition, which show similar
86 characteristics, are thought to be less prone to muscle atrophy than skeletal muscles, and this
87 difference should be considered regarding sarcopenia for these muscles (Fujishima et al., 2019).
88 In addition, the diaphragm has a high percentage of fatigue-resistant fibers (Epstein, 1994).
89 Based on the above, we hypothesized that the diaphragm might be less likely to develop
90 respiratory sarcopenia. Furthermore, because our prior fundamental study showed that MEP was
91 independently associated with skeletal muscle mass index (SMI), we also hypothesized that
92 sarcopenia is more associated with expiratory muscle strength than inspiratory muscle strength
93 (Sawaya et al., 2020).
94   Therefore, this study aimed to determine the most appropriate parameter for assessing
95 respiratory sarcopenia by measuring both respiratory function and respiratory muscle strength.
96 Moreover, we aimed to calculate the cut-off value for the obtained parameter.
97

Materials & Methods

Study design

100 This was a cross-sectional study conducted at a single daycare between March 2018 and August
101 2019. All participants were informed of the study orally and in writing, and written consent was
102 obtained from all participants. The Ethical Review Committee of the International University of
103 Health and Welfare approved this study (Approval No.: 17-Io-189-7). The study complied with
104 the principles of the Declaration of Helsinki.
105

Study participants

107 This study included 154 community-dwelling older adults aged 60 years or older who were
108 under Day Care. All participants had been certified as requiring long-term care/support among
109 the Japanese system (Yamada & Arai, 2020). Our Day Care for older adults involves
110 rehabilitation services that include exercise, transportation, meals, and bathing options. The
111 study included those whose body composition parameters could be measured in the standing
112 position. We excluded those who had been diagnosed as having dementia or aphasia, those for
113 whom performing spirometry was difficult, and those with respiratory diseases such as those on
114 home oxygen therapy or with a forced expiratory volume % in 1 second (FEV1.0%) of <70%,
115 considering the effect of airway obstruction on respiratory function according to a previous study
116 (Kera et al., 2019).
117

Sarcopenia assessment

119 Sarcopenia was diagnosed based on the algorithm of the Asian Working Group for Sarcopenia
120 (AWGS) 2019 (Chen et al., 2020), which was characterized by low skeletal muscle mass, low
121 muscle strength, and/or low physical function. Grip strength was measured twice (Smedley-type
122 hand dynamometer, TKK 5401 Grip-D, Takei Scientific Instruments, Japan) on each side in the

123 sitting position, and the maximum value was used as the representative value. Usual gait speed
124 was measured once at a distance of 5 m using a stopwatch (Arai, 2018). In addition to the
125 measurement section of 5 m, acceleration and deceleration paths were set as walking paths.
126 Skeletal and trunk muscle mass were measured using a multifrequency bioelectrical impedance
127 analysis (BIA) body composition analyzer (InBody 520, InBody, Japan), and the skeletal muscle
128 mass index (SMI) was calculated by dividing the skeletal muscle mass of limbs by the square of
129 the height. The cutoff for each measurement is as follows: grip strength < 28.0 kg for men and <
130 18.0 kg for women, usual gait speed < 1.0 m/sec for both men and for women, and SMI < 7.0
131 kg/m^2 for men and < 5.7 kg/m^2 for women (Chen et al., 2020).
132
133 **Respiratory function and muscle strength**
134 Respiratory function and muscle strength were measured using a spirometer (Autospiro AS-507,
135 Minato, Japan) and an attached unit (AAM377, Minato, Japan). All measurements were
136 performed by physical therapists based on the American Thoracic Society (ATS)/European
137 Respiratory Society (ERS) guidelines (American Thoracic Society/European Respiratory
138 Society, 2002). Respiratory function mode involved FVC, forced expiratory volume in one
139 second (FEV1.0), FEV1.0%, and PEFR. The respiratory muscle strength mode involved MEP
140 and MIP. Respiratory function was measured first, followed by respiratory muscle strength. The
141 maximum value after three measurements was used as the representative value.
142
143 **Basic attributes**
144 Details regarding age, height, care level, smoking history, and morbidity were collected from the
145 medical records of the Day Care. Since long-term certification is classified into seven care levels,
146 this study used an ordinal scale, with a ranking from 1 (mild) to 7 (severe) (Yamada & Arai,
147 2020). Body weight was obtained from the data of body composition measurement.
148
149 **Statistical analyses**
150 First, the basic attributes and measurement values of the sarcopenia and non-sarcopenia groups
151 were compared using the unpaired t-test, Wilcoxon rank-sum test, chi-square test, and Fisher's
152 exact test. Second, binomial logistic regression analysis using stepwise selection was conducted
153 with the presence or absence of sarcopenia as the dependent variable. Respiratory parameters,
154 after considering multicollinearity, were considered as independent variables. Sex, age, care
155 level, body mass index, and morbidity were used as control variables. Third, for the respiratory
156 parameters extracted by binomial logistic regression analysis, the area under the curve (AUC),
157 sensitivity, and specificity were calculated using the Youden Index method from the receiver
158 operating characteristic (ROC) curve, and the cut-off value of sarcopenia was determined.
159 Fourth, the MEP and MIP components were analyzed using partial correlation, controlling for
160 sex and age. The partial correlation was performed after confirming the normal distribution of
161 trunk muscle mass per height squared and SMI by Kolmogorov–Smirnov test and Shapiro–Wilk
162 test. Statistical analysis was performed using SPSS version 25 (IBM Japan, Japan), with a
163 significance level of 5%. Power analysis was performed using G*Power version 3.1.9.2 (Faul et
164 al., 2007).

165

Results

167 Figure 1 shows the flowchart of the study participants. After applying the exclusion criteria,
168 there were 124 eligible participants, 77 with sarcopenia and 47 with non-sarcopenia. Table 1
169 shows a comparison of the basic attributes and measurement values between the sarcopenia and
170 non-sarcopenia groups. The sarcopenia group had a significantly lower MEP for men and PEFR
171 and MEP for women. There was no significant difference in morbidity between the sarcopenia
172 and non-sarcopenia groups.
173   Insert Figure 1 about here.
174   Insert Table 1 about here.
175   Binomial logistic regression analysis showed that MEP was the only respiratory parameter
176 that was significantly associated with sarcopenia (Table 2). Four parameters (FVC, FEV1.0%,
177 PEFR, and MIP) were excluded from the independent variables by the stepwise selection
178 method. FEV1.0 was excluded after multicollinearity was considered. Post-hoc power analysis
179 was performed for binomial logistic regression analysis. For the multiple linear regression of F
180 tests, the power was 0.99, based on the effect size of 0.39, calculated from the regression
181 equation (Nagelkerke R^2=0.281). Analyses by sex are shown in Table S1 and S2. Figure 2 shows
182 ROC curves. The cut-off value of MEP for predicting sarcopenia was 47.0 cmH$_2$0 in men (AUC
183 0.689, sensitivity 91.7%, specificity 41.9%, p=0.011) and 40.9 cmH$_2$0 in women (AUC 0.677,
184 sensitivity 65.2%, specificity 70.6%, p=0.024).
185   Insert Table 2 about here.
186   Insert Figure 2 about here.
187   Table 3 shows the results of the partial correlation analysis. MEP and MIP showed a
188 significant positive correlation (r=0.550) with each other. MEP also showed a significant positive
189 correlation with grip strength, usual gait speed, and SMI, while MIP was not significantly
190 associated with these parameters.
191   Insert Table 3 about here.
192

Discussion

194 In previous reports on sarcopenia and respiratory parameters, skeletal muscle mass was
195 calculated from predictive equations (Ohara et al., 2018; Ohara et al., 2020; Ridwan et al., 2021),
196 and original cut-off values were used for grip strength, walking speed, and SMI for sarcopenia
197 (Kera et al., 2019). This study is the first report to combine (1) compliance with the AWGS2019
198 criteria, (2) skeletal muscle mass measurement using the BIA method recommended by AWGS
199 and EWGSOP (Chen et al., 2020; Cruz-Jentoft et al., 2019), (3) simultaneous analysis of
200 respiratory function and respiratory muscle strength, and (4) compliance with ATS guidelines for
201 spirometry instruments (American Thoracic Society/European Respiratory Society, 2002). Our
202 results showed the lack of significant association between sarcopenia and MIP and FVC as
203 indicators of respiratory sarcopenia and a significant association between sarcopenia and MEP.

204   These findings may be explained by muscle atrophy of the diaphragm and rectus abdominis as

205   well as the component factors of MEP.

206   Sarcopenia was not associated with inspiratory muscle strength of inspiration but with

207   expiratory muscle strength. Muscle fibers are classified into type 1 fibers (slow-oxidative and

208   fatigue-resistant), type 2A fibers (fast-oxidative-glycolytic and fatigue-resistant), and type 2B

209   fibers (fast-glycolytic and fatigue-sensitive) (Epstein, 1994). The diaphragm, which is the main

210   inspiratory muscle, is composed of 80% fatigue-resistant fibers (55% type 1, 25% type 2A),

211   while the rectus abdominis, the main expiratory muscle, is composed of 46% type 2B fibers

212   (Epstein, 1994; Ito, 1998). In sarcopenia, muscle atrophy is selectively observed in fast-twitch

213   fibers (Lexell, Taylor & Sjöström, 1988), suggesting that the diaphragm may be less atrophic and

214   maintain its inspiratory muscle strength, while the rectus abdominis may be more prone to

215   atrophy and loss of expiratory muscle strength. These supportive reports indicate that the

216   diaphragm shows very little change in muscle mass and strength with aging (Krumpe et al.,

217   1985; Caskey et al., 1989; Polkey et al., 1997; Mizuno, 1991). Although a study reported that the

218   diaphragm is significantly thinner in older adults with sarcopenia, it is not clear whether the

219   change is clinically significant because only a difference of 0.2–0.4 mm was noted (Deniz et al.,

220   2021).

221   Next, we performed a partial correlation analysis, focusing on the component factors of

222   MEP and MIP. Although the MEP and MIP of the participants in this study were correlated, only

223   MEP showed a significant association with grip strength, walking speed, and SMI, which are

224   indicators of sarcopenia. Trunk muscle mass was also found to have a significant association

225   only with MEP. These results suggest that the component factors of MEP and MIP are different,

226   and that MEP may contain sarcopenia elements, while MIP does not. However, the association

227   between these sarcopenia parameters and MEP/MIP is inconsistent across research populations

228   (Shin et al., 2017; Bahat et al., 2014); thus, further research is needed. For the remaining

229   respiratory function parameters, binomial logistic regression analysis did not show a significant

230   association with sarcopenia in the overall and gender-specific analyses.

231   Our results showed that the cut-off value of MEP for predicting sarcopenia was 47.0

232   cmH_2O for men and 40.9 cmH_2O for women. Only one previous study with a Brazilian population

233   calculated a similar cut-off value for MEP, which was 60.0 cmH_2O for men and 50.0 cmH_2O for

234   women (Ohara et al., 2018). Our study demonstrates acceptable results because the respiratory

235   muscle strength of Asian ethnic groups is low owing to their small body size (Chen & Kuo,

236   1989). FVC and PEFR, which are parameters of respiratory sarcopenia in previous studies, may

237   be difficult to obtain for older adults even if they have no cognitive problems, because obtaining

238   these parameters requires several repetitive breaths of varying intensity (Nagano et al., 2021;

239   Kera et al., 2019). However, MEP only requires maximal expiratory effort from the maximal

240   inspiratory position, which has the advantage of being easy to obtain.

241   This study has several limitations. Our participants were older adults requiring long-term

242   care/support and may have been affected by disease conditions. However, it is difficult to

243   determine whether sarcopenia and respiration are affected by primary (aging) or secondary

244 (disease, etc.) factors. For this reason, we included them as control variables in the binomial
245 logistic regression analysis. Since the multimorbidity of older Japanese adults was 62.8%, we
246 could not eliminate disease-related factors (Aoki et al., 2018). The fact that the population had a
247 high sarcopenia prevalence and a low AUC value, the generalizability of this study requires
248 further survey among healthy individuals. Although MEP was found to predict whole-body
249 sarcopenia in this study, these findings do not indicate that MEP is associated with future
250 sarcopenic respiratory disability. Future longitudinal studies with a large sample size are needed
251 to clarify the clinical significance of each parameter in respiratory sarcopenia.
252
253 **Conclusions**
254 The most appropriate parameter for assessing respiratory sarcopenia may be MEP, which is an
255 indicator of expiratory muscle strength, instead of FVC, MIP, or PEFR, as suggested in previous
256 studies. It easy to instruct patients for MEP measurement. MEP is expected to be applied in
257 clinical practice.
258
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261

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Table 1. Basic attributes and measurements values with and without sarcopenia

*P < 0.05 for unpaired t test. **P < 0.05 for Wilcoxon rank-sum test. [†]Median (25th percentile–75th percentile). [††]With missing data (63 men, 55 women). BMI, body mass index; SMI, skeletal muscle mass index; FVC, forced vital capacity; FEV1.0, forced expiratory volume in 1 second; PEFR, peak expiratory flow rate; MEP, maximal expiratory pressure; MIP, maximal inspiratory pressure; dis, disease.

1 **Table 1. Basic attributes and measurements values with and without sarcopenia**

	Men (n=67)			Women (n=57)		
	Sarcopenia (n=43)	Non-sarcopenia (n=24)	P-value	Sarcopenia (n=34)	Non-sarcopenia (n=23)	P-value
Age (years)	77.5 ± 7.9	73.4 ± 7.6	0.041*	77.4 ± 8.0	80.0 ± 9.5	0.269
Height (cm)	161.3 ± 5.4	165.6 ± 6.2	0.004*	150.3 ± 5.7	153.9 ± 5.2	0.019*
Weight (kg)	57.6 ± 6.6	65.6 ± 7.8	<0.001*	46.3 ± 8.0	56.6 ± 7.9	<0.001*
BMI (kg/m^2)	22.2 ± 2.6	24.0 ± 3.0	0.012*	20.6 ± 4.0	23.9 ± 3.1	0.001*
Care level (1–7)†	3 (2–3)	3 (2–4)	0.659	3 (2–4)	2 (1–3)	0.011**
Smoking history††	28	12	0.411	1	0	1.000
Sarcopenia assessment						
Grip strength (kg)	22.9 ± 5.6	31.0 ± 5.0	<0.001*	15.6 ± 4.8	19.0 ± 4.6	0.010*
Usual gait (m/s)	0.64 ± 0.27	0.77 ± 0.34	0.085	0.52 ± 0.24	0.68 ± 0.39	0.084
SMI (kg/m^2)	6.07 ± 0.57	7.40 ± 0.78	<0.001*	5.13 ± 0.44	6.28 ± 0.48	<0.001*
Trunk muscle mass per square height (kg/m^2)	6.99 ± 0.75	7.84 ± 0.90	<0.001*	6.29 ± 0.57	6.88 ± 0.62	0.001*
Respiratory function						
FVC (L)	2.23 ± 0.68	2.52 ± 0.64	0.096	1.55 ± 0.40	1.66 ± 0.43	0.352
FEV1.0 (L)	1.88 ± 0.56	2.10 ± 0.59	0.120	1.35 ± 0.35	1.41 ± 0.37	0.561
FEV1.0% (%)	84.5 ± 7.4	83.8 ± 8.5	0.736	87.2 ± 6.9	84.8 ± 7.1	0.197
PEFR (L/s)	4.20 ± 1.48	4.69 ± 1.90	0.244	2.91 ± 1.03	3.56 ± 1.26	0.038*
Respiratory muscle strength						
MEP (cmH$_2$O)	52.8 ± 18.4	67.7 ± 23.9	0.006*	36.2 ± 12.6	45.7 ± 14.6	0.011*
MIP (cmH$_2$O)	38.3 ± 20.6	43.6 ± 16.2	0.282	29.8 ± 10.8	33.0 ± 18.2	0.464
Morbidity						
Hypertension	17	10	1.000	15	10	1.000
Cerebrovascular dis	23	16	0.317	14	7	0.576
Orthopedic dis	22	9	0.317	25	17	1.000
Cancer	11	4	0.545	5	4	1.000
Intractable neurological dis	9	4	0.757	5	1	0.385

2 *P < 0.05 for unpaired t test.

3 **P < 0.05 for Wilcoxon rank-sum test.

4 †Median (25th percentile–75th percentile).

5 ††With missing data (63 men, 55 women).

6 BMI, body mass index; SMI, skeletal muscle mass index; FVC, forced vital capacity; FEV1.0, forced

7 expiratory volume in 1 second; PEFR, peak expiratory flow rate; MEP, maximal expiratory pressure; MIP,

8 maximal inspiratory pressure; dis, disease.

Table 2. Association between sarcopenia and respiratory parameters based on binomial logistic regression analysis

CI, confidence interval; MEP, maximal expiratory pressure; BMI, body mass index. Dependent variables: Non-sarcopenia=0, sarcopenia=1. Independent variables: Men=0, women=1; without morbidity=0, with morbidity=1. Nagelkerke R^2=0.281.

1 **Table 2. Association between sarcopenia and respiratory parameters based on**

2 **binomial logistic regression analysis**

	β	P-value	Odds ratio	95%CI
MEP (cmH$_2$O)	-0.028	0.034	0.973	0.948–0.998
Sex	-0.988	0.056	0.373	0.135–1.028
Age (years)	-0.004	0.868	0.996	0.945–1.049
BMI (kg/m^2)	-0.239	0.002	0.788	0.677–0.916
Certification (1–7)	0.323	0.052	1.381	0.998–1.911
Hypertension	0.275	0.540	1.316	0.547–3.171
Cerebrovascular disease	-0.116	0.819	0.890	0.330–2.400
Orthopedic disease	0.248	0.608	1.282	0.496–3.310
Cancer	-0.243	0.655	0.784	0.270–2.278
Intractable neurological disease	0.037	0.959	1.037	0.258–4.167

3 CI, confidence interval; MEP, maximal expiratory pressure; BMI, body mass index.

4 Dependent variables: Non-sarcopenia=0, sarcopenia=1.

5 Independent variables: Men=0, women=1; without morbidity=0, with morbidity=1.

6 Nagelkerke R^2=0.281.

Table 3. Partial correlation of MEP and MIP with component factors

Controlling for sex and age. BMI, body mass index; SMI, skeletal muscle mass index; MEP, maximal expiratory pressure; MIP, maximal inspiratory pressure.

1 **Table 3. Partial correlation of MEP and MIP with component factors**

	MEP	P-value	MIP	P-value
Height (cm)	0.116	0.203	0.019	0.834
Weight (kg)	0.370	<0.001	0.204	0.024
BMI (kg/m^2)	0.315	<0.001	0.199	0.028
Grip strength (kg)	0.263	0.003	0.075	0.411
Usual gait (m/s)	0.238	0.008	0.124	0.173
SMI (kg/m^2)	0.276	0.002	0.075	0.414
Trunk muscle mass per height squared (kg/m^2)	0.315	<0.001	0.098	0.281
MEP (cmH$_2$O)	—	—	0.550	<0.001
MIP (cmH$_2$O)	0.550	<0.001	—	—

2 Controlling for sex and age.

3 BMI, body mass index; SMI, skeletal muscle mass index; MEP, maximal expiratory pressure;

4 MIP, maximal inspiratory pressure.

Figure 1

Figure 1. Flowchart of participant recruitment

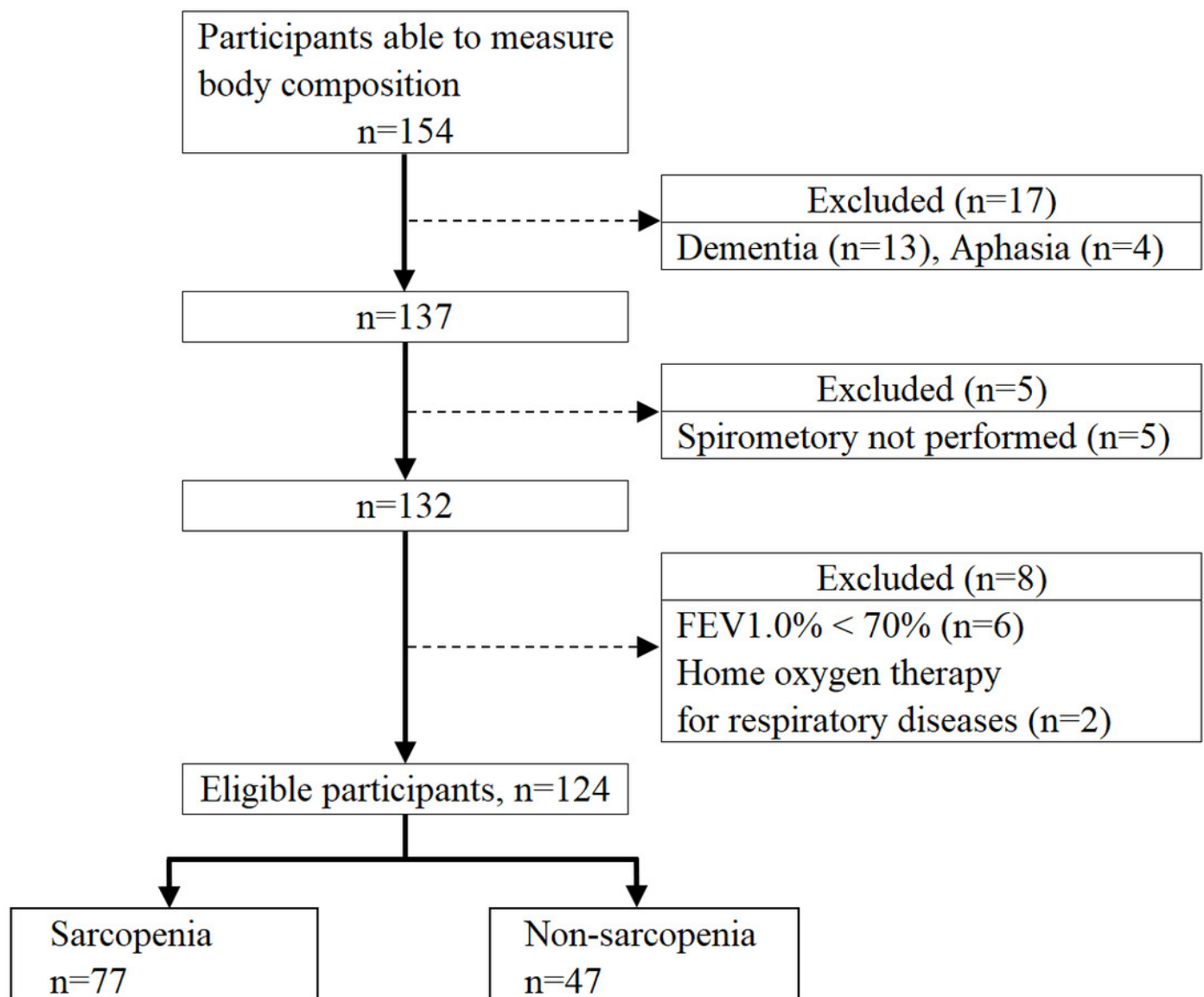
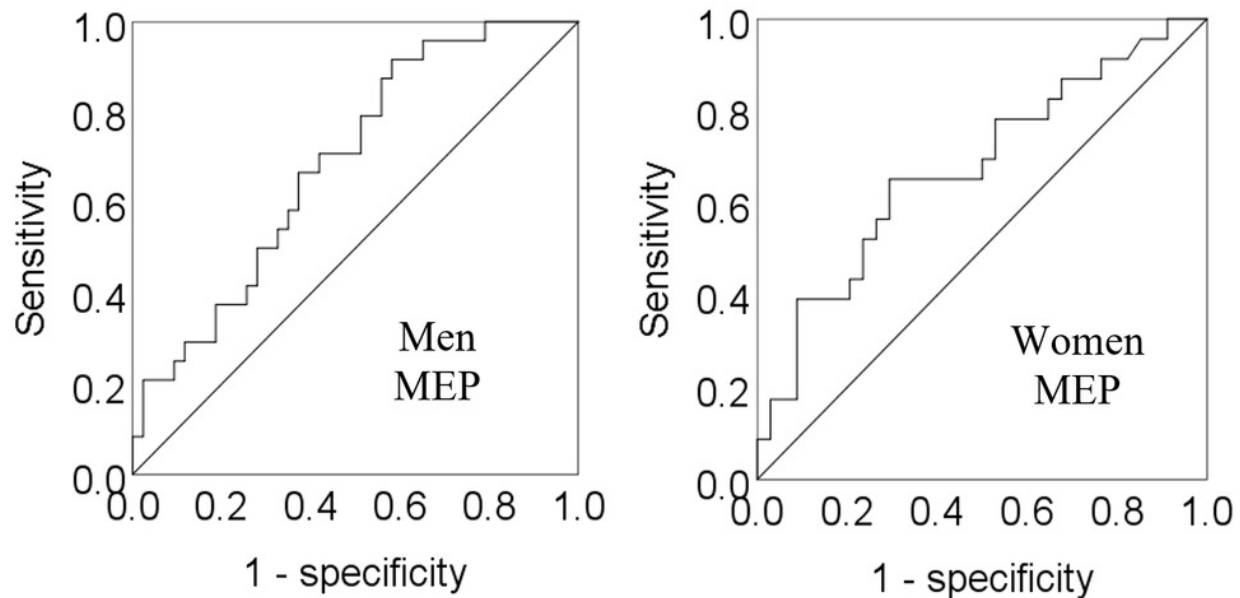



Figure 2

Figure 2. Receiver operating characteristic curve analysis for identifying sarcopenia via MEP

	Cut-off	Sensitivity	Specificity	AUC	95%CI	P value
Men	47.0 cmH$_2$O	91.7%	41.9%	0.689	0.562-0.816	0.011*
Women	40.9 cmH$_2$O	65.2%	70.6%	0.677	0.533-0.821	0.024*

MEP, maximal expiratory pressure; AUC, area under the curve; CI, confidence interval.
* $P < 0.05$.