




# The Prevalence of Sarcopenic Obesity in Postmenopausal Women with a History of Breast Cancer Depending on Adopted Methodology – A Case–Control Study

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**Introduction:** Sarcopenic obesity (SO) is characterized as the cooccurrence of sarcopenia and obesity. It is associated with many adverse health consequences, also in oncological patients. The study aimed to assess the prevalence of SO in postmenopausal women with a history of breast cancer depending on adopted methodology.

**Materials and Methods:** The case–control study enrolled 103 women over the age of 50 with a history of breast cancer, including women who completed oncological treatment and had remained in remission for at least 5 years (group I, n=78) and women in whom the disease recurred (group II, n=25). The control group included women with no history of breast cancer (group III, n=73).

**Results:** In group II sarcopenia occurred significantly more commonly compared to both group I and the control group (for the skeletal muscle index (SMI)  $\leq 29.20\%$ : 13 (52%) in group II vs 16 (20.5%) in group I,  $p=0.004$  and 3 (4.1%) in group III,  $p<0.001$ ; for SMI  $\leq 26.60\%$ : 10 (40%) in group II vs 9 (11.5%) in group I,  $p=0.003$  and 3 (4.1%) in group III,  $p<0.001$ ; for SMI  $\leq 33.87\%$ : 17 (68%) in group II vs 21 (26.9%) in group I,  $p<0.001$  and 5 (6.8%) in group III,  $p<0.001$ ). Depending on the assessment criteria, SO was diagnosed in 0–11.5% of cases in group I, 0–40% of cases in group II and 0–4.1% in the control group. Intergroup differences were not statistically significant, irrespective of the adopted pair of diagnostic criteria. The highest detectability of SO was observed when SMI was combined with each of the diagnostic criteria for obesity used.

**Discussion:** SO diagnosis based on the percentage of fatty tissue mass in the body of  $>38\%$  and SMI value were associated with a higher detection rate of SO in each study group, regardless of the adopted cut-off value. Similar results were obtained in each analyzed group when using the remaining diagnostic criteria for obesity and SMI value, regardless of the cut-off value.

**Keywords:** sarcopenia, obesity, breast neoplasms, muscles, menopause, aging

The assessment of body composition has gained a lot of interest in oncology as it may affect the effectiveness of chemotherapy, the frequency of surgery-related complications, the duration of hospital stay and the overall survival rate. It was corroborated by the results published by Prado et al, Antoun et al, Liefers et al and Cecchini et al.<sup>1,9,27,34</sup>

The association between obesity and the risk of developing numerous tumors, including breast cancer, has been confirmed by strong evidence.<sup>2,26,29,32,37</sup> Furthermore, obesity may constitute a poor prognostic factor in case of this

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tumor. A meta-analysis of 82 studies, which comprised over 200,000 patients, showed that the risk of death was higher by 75% in premenopausal women and by 34% in postmenopausal women if they were obese at the moment of breast cancer diagnosis, compared to patients with normal body weight.<sup>11</sup> Moreover, a strong correlation was demonstrated between obesity and the risk of breast cancer recurrence and death regardless of the fact that the patient was pre- or postmenopausal.<sup>46</sup> A meta-analysis of 12 studies, which included 23,832 women, showed that if body weight increased by at least 5% of initial body weight after the diagnosis of breast cancer, the patient was at an increased risk of death due to all causes compared to patients whose body weight did not change (HR, 1.12; 95% CI, 1.03–1.22). The risk of death was the highest in patients whose body weight increased by at least 10%.<sup>33</sup>

The assessment of adipose tissue mass may be performed with the use of numerous parameters. However, the most common one is body mass index (BMI) defined as body weight/height<sup>2</sup> (kg/m<sup>2</sup>).<sup>47</sup> Regrettably, the assessment of the nutritional status with BMI is commonly insufficient. Observations by Cespedes Feliciano et al demonstrated the limitations of the sole use of BMI in oncological patients. BMI scales body weight to height without comprising such parameters as adipose tissue distribution and the differentiation between adipose tissue and muscle tissue.<sup>10</sup> Excessive adipose tissue may mask the loss of muscle mass in oncological patients. The appropriate body composition assessment necessitates adequate diagnostic procedures of sarcopenia and sarcopenic obesity.

Sarcopenia is a myopathy caused by unfavorable changes characterized by lifelong progression. Sarcopenia is common in elderly people, but it may also occur in younger individuals.<sup>14</sup> It is defined as the loss of muscle mass and function. Menopause is associated with numerous changes in body composition. The changes are predominantly associated with the reduction of the fat-free mass index, including the loss of skeletal muscle, which translates into the decreased strength of muscle contraction. During menopause, the adipose tissue mass increases both generally, and in the central location.<sup>47</sup> Sarcopenic obesity (SO) is a new category of obesity, which refers to sarcopenia concomitant with obesity. Its occurrence, especially in the group of oncological patients, is associated with numerous consequences. Therefore, the diagnostics of sarcopenic obesity should become an element of routine proceedings.<sup>41</sup>

The results of numerous studies indicate that oncological patients in whom sarcopenia was diagnosed are characterized by higher morbidity and mortality rates.<sup>4,6,31,35,42</sup> A correlation between the occurrence of sarcopenia and poorer prognosis in patients with early breast cancer was observed by Deluche et al.<sup>16</sup> Furthermore, research conducted by Villaseñor et al emphasized the relationship between the occurrence of sarcopenia and overall mortality in patients with breast cancer and the possible influence on breast cancer-related mortality.<sup>44</sup> Bandera and John noted that the death risk in the group of women with breast cancer with concomitant sarcopenia was higher than in patients without sarcopenia.<sup>5</sup>

Lieffers et al demonstrated that patients with colon cancer and concomitant sarcopenia were at risk of adverse effects following colon surgery.<sup>27</sup> Prado et al showed that SO constituted a significant prognostic factor in patients with digestive and respiratory system tumors.<sup>35</sup> Patients with sarcopenic obesity were characterized by a poorer functional status and shorter overall survival rate. Similar conclusions were drawn from a study conducted in patients with advanced pancreatic cancer. SO was an unfavorable prognostic factor and contributed to lower survival rate.<sup>42</sup>

However, not all studies revealed similar results. Awad et al demonstrated that adipose tissue mass and fat-free mass were not associated with hospital mortality or survival in patients with esophagogastric cancer.<sup>3</sup> Similar conclusions were presented by Hamer and O'Donovan who analyzed the relationship between SO in a group of 6864 patients with no history of oncological conditions.<sup>22</sup>

The aim of the study

The study aimed to assess the prevalence of SO in postmenopausal women with a history of breast cancer depending on adopted methodology.

## Materials and Methods

The case-control study was conducted in Warsaw and the neighboring area. It included women with a history of breast cancer (patients of selected hospitals and members of oncological associations) and their female acquaintances and relatives who were oncologically healthy. The women were informed about the study via banners and leaflets. Furthermore, the information concerning the possibility of participating in the study was also passed by the attending physician. At baseline, all the participants had a document issued by their gynecologist which confirmed that they entered menopause.

The selection of the method of body composition analysis (BIA – Bioelectrical Impedance Analysis) necessitated the following exclusion criteria: confirmed epilepsy, implanted cardiac pacemaker or defibrillator and metal endoprosthesis. Moreover, women with renal or hepatic failure, as well as a metastatic process were excluded. Inclusion criteria were met by 173 women over the age of 50, including 103 women with a history of breast cancer. The participants were divided into three groups. Group I (n=78) included women who had completed oncological treatment and had been in remission for at least 5 years. Group II (n=25) included women who had completed oncological treatment in the past, and in whom the disease recurred. Group III (n=73) was made up of women with no history of breast cancer. The occurrence of sarcopenic obesity was assessed in all the groups.

Body weight was measured with electronic scales in increments of 0.1 kg according to generally accepted measurement standards. The results were used to calculate BMI values (body weight (kg)/height (cm)<sup>2</sup>). BMI ranges corresponding to normal and low body weight, being overweight and obese were consistent with the recommendations of the WHO. The measurement of hand grip strength of the non-dominant hand was performed twice with a hydraulic SAEHAN dynamometer. Subsequently, the higher value was selected.

Due to changes introduced by EWGSOP2 the cut-off value for sarcopenia was set at 16 kg (instead of 20 kg, as previously assumed in research).<sup>12,13</sup>

Body composition was estimated by means of bioelectrical impedance method with the use of Bioscan 920–2 device (Maltron Int, UK) at 4 frequencies (5, 50, 100 and 200 kHz). The patient was in a lying position with the limbs abducted from the body axis by 30 degrees. The basic test was performed in a single-channel tetrapolar system on the right side of the body. The application site was cleansed with an alcohol wipe. Then, electrodes were applied 5 cm apart on the dorsal central part of the hand between the carpal joint and the 3rd metacarpophalangeal joint and on the dorsal central part of the foot between the tarsal joint and the 3rd metatarsophalangeal joint, 5 cm apart.<sup>19</sup>

Study participants were supposed to meet the conditions of the guidelines concerning body composition measurements issued by the European Society for Clinical Nutrition and Metabolism (ESPEN). On the day of examination, the participants had to refrain from eating, void urine 30 minutes before the test, refrain from physical

activity for 12 hours prior to the test, resign from the consumption of alcohol or caffeinated beverages for 24 hours prior to the test.<sup>19</sup>

Basing on the performed tests of body composition and anthropometric measurements the following values were determined:

- fat mass – FM (%),
- fat mass index – FMI (kg/m<sup>2</sup>) calculated on the basis of the formula: body fat mass [kg]/height [m]<sup>2</sup>,<sup>40</sup>
- skeletal mass index – SMI (%) according to the formula: [muscle mass [kg]/(body weight [kg]/100)],<sup>23</sup>
- muscle mass index – MMI (kg/m<sup>2</sup>) according to the formula: [muscle mass [kg]/(height [m])<sup>2</sup>],<sup>7,43</sup>
- fat-free mass index – FFMI (kg/m<sup>2</sup>) according to the formula: fat-free mass index [kg]/(height [m])<sup>2</sup>,<sup>40</sup>
- appendicular skeletal mass index – ASMI (kg/m<sup>2</sup>); ASMI cut-off value (proposed by EWGSOP2 as a criterion for diagnosing sarcopenia) was used in place of MMI in the present study because of the selected method of body composition testing.<sup>14</sup>

Obesity was diagnosed when at least one of the following criteria was met:

- BMI  $\geq 30$  kg/m<sup>2</sup>,
- FM  $> 38\%$ ,<sup>43</sup>
- FMI  $> 11.8$  kg/m<sup>2</sup>.<sup>40</sup>

The adopted cut-off values according to various authors are presented in Table 1. The results obtained in Group III could not be used to determine the cut-off values for the group, because according to Cruz-Jentoft et al they can only be defined for the population of 18–39 years old.<sup>13</sup>

Sarcopenia was defined in accordance with EWGSOP2 guidelines as of 2018 if low muscle mass and low muscle strength were noted. Due to the fact that the present study had been performed before the publication of those guidelines physical fitness was not assessed.<sup>13</sup> Sarcopenic obesity was diagnosed when two conditions were met simultaneously: obesity and sarcopenia.

The obtained results were analyzed with Maltron BioScan 920 v. 1.1.135 and Statistica 13.3 (TIBCO Software Inc.). The normality of distribution was tested with the Shapiro–Wilk test. Testing differences between values was performed with the *t*-Student test or the two-tailed Fisher's exact test. If the dependent variable was not normally distribution the Mann–

**Table 1** Diagnostic Criteria and Cut-off Points Used for the Identification of Sarcopenia

Index and Population	Criteria	Cut-Off Value
SMI French population, according to Tichet <sup>43</sup>	$\leq 2$ SD compared to the mean value of SMI* <sup>23,43</sup>	26.60%
SMI Polish population, according to Siemaszko <sup>24</sup>	$\leq 2$ SD compared to the mean value of SMI* <sup>23,43</sup>	33.87%
SMI Polish population, according to Milewska <sup>30</sup>	$\leq 2$ SD compared to the mean value of SMI* <sup>23,43</sup>	29.02%
MMI French population, according to Tichet <sup>43</sup>	$\leq 2$ SD compared to the mean value of MMI* <sup>23,43</sup>	6.2 kg/m <sup>2</sup>
MMI Polish population according to Siemaszko <sup>24</sup>	$\leq 2$ SD compared to the mean value of MMI* <sup>23,43</sup>	7.12 kg/m <sup>2</sup>
MMI Polish population, according to Milewska <sup>30</sup>	$\leq 2$ SD compared to the mean value of MMI* <sup>23,43</sup>	6.61 kg/m <sup>2</sup>
ASMI and hand grip strength according to EWGSOP2 <sup>13</sup>	—	6 kg and 16 kg, respectively
MM and hand grip strength according to EWGSOP2 <sup>13</sup>	—	15 kg and 16 kg, respectively
FFMI Polish population, according to Milewska <sup>30</sup>	$\leq 2$ SD compared to the mean value of FFMI* <sup>7</sup>	14.59 kg/m <sup>2</sup>

**Note:** \*Cut-off points were determined for a group of oncologically healthy individuals aged 18–39.

**Abbreviations:** SMI, skeletal mass index (5); MMI, muscle mass index (kg/m<sup>2</sup>); FFMI, fat-free mass index (kg/m<sup>2</sup>).

Whitney U-test or Kruskal–Wallis ANOVA test (with Dunn's post hoc test with Bonferroni correction) was used. For all analyses, a P-level of <0.05 was considered statistically significant.

## Results

Table 2 shows detailed characteristics of the participants. The average age in group I was 67.33±7.03 years, in group II it was 70.92±8.17 and in group III it was 65.44±6.22 years. Group II women were characterized by a significantly higher body mass index (29.03±5.31 vs 26.64±4.21,  $p=0.05$ ) and muscle mass (19.80±2.79 vs 19.36±1.90,  $p=0.013$ ) compared

to the control group. Moreover, significantly lower values of hand grip strength were noted in group II compared to other groups (12.76±3.97 vs 17.53±4.87 in group I,  $p<0.001$  and 21.82±5.77 in group III,  $p<0.001$ ).

The diagnosis of sarcopenia based on the muscle mass index (MMI) with the use of the cut-off point determined for the Polish population after Milewska revealed 3.8% ( $n=3$ ) of women with sarcopenia in group I and 4% ( $n=1$ ) of women in group II. When adopting the cut-off values determined for the French population sarcopenia was diagnosed in 1.3% of group I participants ( $n=1$ ) and in 4% of persons from group II ( $n=1$ ). When adopting the cut-off values determined for the Polish population by Siemaszko, sarcopenia was identified in 14.1% of persons in group I ( $n=11$ ) and in 20% in group II ( $n=5$ ). The differences which occurred when the MMI criterion was used were statistically significant only as regards the control group (group I vs III  $p=0.005$ ; group II vs III  $p=0.004$ ).

Basing on the SMI criterion of sarcopenia classification and the cut-off value determined by Milewska et al, sarcopenia was diagnosed in 20.5% of persons from group I ( $n=16$ ) and 52% from group II ( $n=13$ ). The differences were statistically significant ( $p=0.004$ ). When adopting the cut-off values determined by Tichet, sarcopenia was diagnosed in 11.5% of group I participants ( $n=9$ ) and in 40% of persons from group II ( $n=10$ ) ( $p=0.003$ ). The criteria proposed by Siemaszko showed sarcopenia in 26.9% of women in group I ( $n=21$ ) and in 68% of women in group II ( $n=17$ ) ( $p<0.001$ ).

When adopting the cut-off values indicated by Milewska based on the FFMI, sarcopenia was identified in 4% of persons in group II ( $n=1$ ). Nobody was diagnosed with sarcopenia in group I. However, the differences were statistically insignificant. Detailed results are presented in Table 3.

The frequency of obesity in individual groups of women identified with various diagnostic criteria are presented in Table 4. Statistically significant differences were only observed in diagnosing obesity with the BMI criterion.

Matching the results concerning the diagnosis of sarcopenia and identification of obesity revealed rather diversified findings regarding SO prevalence. The results ranged from 0% to 11.5% in group I and from 0% to 40% in group II. The lowest percentage of SO was revealed based on the FFMI and MMI indices regardless of the adopted cut-off value and in the case of the MM and ASMI combined with hand grip strength. The highest SO detectability was obtained with the use of the skeletal

**Table 2** Characteristics of Subjects According to Groups

Parameter	Statistical Measure	Group I (N = 78)	Group II (N = 25)	Group III (N = 73)	ANOVA K-W*		I vs II**		I vs III**		II vs III**	
					H	p	z	p	z	p	z	p
Age [years]	M±SD Mdn Min-Max	67.33±7.03 67.00 51–86	70.92±8.17 72.00 50–85	65.44±6.22 66.00 51–83	11.02	0.004	2.62	0.027	1.03	0.902	3.31	0.003
Height [cm]	M±SD Mdn Min-Max	161.70±5.14 162.00 150–176	160.20±4.55 160.00 149–170	162.47±5.375 162.00 147–176	1.73	0.421	–	–	–	–	–	–
Body weight [kg]	M±SD Mdn Min-Max	69.68±11.97 68.00 47–120	74.48±13.75 75.00 44–100	70.23±10.97 70.00 39–96	5.33	0.070	–	–	–	–	–	–
BMI [kg/m <sup>2</sup> ]	M±SD Mdn Min-Max	26.63±4.13 26.26 17.06–41.52	29.03±5.31 28.26 17.85–37.65	26.64±4.21 26.62 17.57–37.11	6.18	0.047	2.30	0.065	0.10	1.000	2.34	0.05
FFM [kg]	M±SD Mdn Min-Max	44.80±4.25 44.31 36.51–59.79	45.48±4.48 45.98 34.60–57.57	45.04±4.41 44.71 30.66–54.58	2.02	0.364	–	–	–	–	–	–
FFM [%]	M±SD Mdn Min-Max	64.97±6.79 65.07 49.83–87.49	62.30±7.93 61.64 51.10–78.64	65.33±7.79 64.44 52.02–84.78	3.31	0.191	–	–	–	–	–	–
FM [kg]	M±SD Mdn Min-Max	25.18±8.83 23.85 5.88–60.21	29.04±10.71 26.71 9.40–48.22	24.96±8.62 25.41 7.46–45.58	4.26	0.119	–	–	–	–	–	–
FM [%]	M±SD Mdn Min-Max	35.03±6.79 34.94 12.51–50.18	37.70±7.93 38.36 21.36–48.90	34.67±7.79 35.56 15.22–47.98	3.31	0.191	–	–	–	–	–	–
MM [kg]	M±SD Mdn Min-Max	19.15±1.94 19.08 15.65–25.68	19.80±2.79 19.43 14.80–29.54	19.36±1.90 19.43 12.97–23.31	8.23	0.016	2.27	0.070	0.86	1.000	2.86	0.013
FFMI [kg/m <sup>2</sup> ]	M±SD Mdn Min-Max	17.11±1.12 17.07 14.78–20.69	17.723±1.51 17.98 14.04–20.09	17.04±1.18 17.07 14.19–19.58	5.28	0.071	–	–	–	–	–	–
FMI [kg/m <sup>2</sup> ]	M±SD Mdn Min-Max	9.63±3.24 9.36 2.13–20.83	11.32±4.19 10.72 3.81–18.09	9.50±3.37 9.58 2.67–17.80	3.71	0.156	–	–	–	–	–	–
SMI [%]	M±SD Mdn Min-Max	27.86±2.73 27.79 21.40–35.77	27.11±4.22 26.46 21.98–39.39	27.99±3.47 27.57 20.84–36.57	2.16	0.340	–	–	–	–	–	–
MMI [kg/m <sup>2</sup> ]	M±SD Mdn Min-Max	7.32±0.52 7.30 5.93–8.89	7.72±1.13 7.70 6.00–12.30	7.32±0.49 7.33 6.00–8.38	4.32	0.116	–	–	–	–	–	–
Hand grip strength [kg]	M±SD Mdn Min-Max	17.53±4.87 18.00 6–30	12.76±3.97 11.00 8.00–18.00	21.82±5.77 20.00 8–38	47.52	<0.001	3.79	<0.001	4.03	<0.001	6.59	<0.001

**Notes:** \*Kruskal–Wallis ANOVA test \*\*Dunn's post hoc test with Bonferroni correction.

**Abbreviations:** M, mean; SD, standard deviation; Mdn, median; Min-Max, range of measurements; ns, not significant; BMI, Body Mass Index; FFM, fat-free mass; FM, fat mass; MM, muscle mass; FFMI, fat-free mass index; SMI, skeletal muscle index; MMI, muscle mass index.



**Table 3** Prevalence of Sarcopenia in Subjects According to Groups

Sarcopenia Diagnostic Criteria	Group I N = 78	Group II N = 25	Group III N = 73	p (I vs II) <sup>1</sup>	p (I vs III) <sup>1</sup>	p (II vs III) <sup>1</sup>
	n (%)					
MMI ≤ 6.61 kg/m <sup>2</sup> *	3 (3.8)	1 (4)	1 (1.4)	1.000	0.621	0.447
MMI ≤ 6.2 kg/m <sup>2</sup> **	1 (1.3)	1 (4)	1 (1.4)	0.428	1.000	0.447
MMI ≤ 7.12 kg/m <sup>2</sup> ***	11 (14.1)	5 (20)	1 (1.4)	0.529	0.005	0.004
SMI ≤ 29.20% *	16 (20.5)	13 (52)	3 (4.1)	0.004	0.003	<0.001
SMI ≤ 26.6% **	9 (11.5)	10 (40)	3 (4.1)	0.003	0.132	<0.001
SMI ≤ 33.87% ***	21 (26.9)	17 (68)	5 (6.8)	<0.001	0.011	<0.001
FFMI ≤ 14.59 kg/m <sup>2</sup> *	0 (0)	1 (4)	1 (1.4)	0.243	0.483	<0.001
MM < 15 kg and hand grip strength < 16 kg ****	0 (0)	1 (4)	1 (4)	0.243	0.483	1.000
ASMI < 6 kg/m <sup>2</sup> and hand grip strength < 16 kg ****	0 (0)	0 (0)	0 (0)	–	–	–

**Notes:** <sup>1</sup>Two-tailed Fisher's exact test. In the present study: \*With reference to cut-off points according to Milewska,<sup>30</sup> \*\*With reference to cut-off points according to Tichet,<sup>43</sup> \*\*\*With reference to cut-off points according to Siemaszko,<sup>24</sup> \*\*\*\*With reference to cut-off points according to EWGSOP2.<sup>13</sup>

**Abbreviations:** MMI, muscle mass index; SMI, skeletal mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle index.

**Table 4** Prevalence of Obesity in Subjects According to Groups

Obesity Diagnostic Criteria	Group I N = 78	Group II N = 25	Group III N = 73	p (I vs II) <sup>1</sup>	p (I vs III) <sup>1</sup>	p (II vs III) <sup>1</sup>
	n (%)					
BMI ≤ 30 kg/m <sup>2</sup>	17 (21.8)	11 (44)	16 (21.9)	0.039	1.000	0.041
FM > 38%	30 (38.5)	14 (56)	27 (37)	0.164	0.868	0.107
FMI ≤ 11.8 kg/m <sup>2</sup>	19 (24.4)	9 (36)	17 (23.3)	0.304	1.000	0.293

**Note:** <sup>1</sup>Two-tailed Fisher's exact test.

**Abbreviations:** BMI, body mass index; FM, fat mass; FMI, fat mass index.

muscle index (SMI) regardless of the adopted cut-off value and the criterion for diagnosing obesity. However, it needs to be emphasized that no statistical significance was noted in the case of any of the observed differences in diagnosing SO with the use of various pairs of criteria. Detailed results are presented in [Table 5](#).

## Discussion

According to some criteria, sarcopenia was significantly more common in women with the recurrence of breast cancer than in women in remission and in women with no history of breast cancer (for SMI ≤ 29.20%: 13 (52%) in group II vs 16 (20.5%) in group I,  $p=0.004$  and 3 (4.1%) in group III,  $p<0.001$ ; for SMI ≤ 26.60%: 10 (40%) in group II vs 9 (11.5%) in group I,  $p=0.003$  and 3 (4.1%) in group III,  $p<0.001$ ; for SMI ≤ 33.87%: 17 (68%) in group II vs 21 (26.9%) in group I,  $p<0.001$  and 5 (6.8%) in group III,  $p<0.001$ ). Such a phenomenon may occur due to numerous factors. It seems essential to consider the duration of the neoplastic disease and the related treatment. Furthermore, oncological patients frequently experience fatigue, which

translates into reduced physical activity. Neoplastic diseases and implemented oncological treatment are commonly responsible for loss of appetite. Therefore, muscle mass may be reduced, and sarcopenia may develop in patients with oncological diseases.<sup>11</sup>

SO, which is a combination of obesity and sarcopenia, was diagnosed with three different diagnostic criteria for obesity and nine diagnostic criteria for sarcopenia. The total combination count was 27. The obtained differences in the frequency of SO diagnosed with various pairs of criteria both within particular groups and between groups did not reach the level of statistical significance. It is worth emphasizing that SO diagnosis based on the percentage of fatty tissue mass in the body of >38% and the SMI value was associated with a higher detection rate of SO in each study group, regardless of the adopted cut-off value. Furthermore, similar results were obtained in each analyzed group when using the remaining diagnostic criteria for obesity and the SMI value, regardless of the cut-off value. SMI is the only index that comprises muscle mass and body weight, which makes it more significant in SO diagnostics in individuals with excessive adipose tissue. It

**Table 5** Prevalence of Sarcopenic Obesity in Subjects According to Groups

Sarcopenia Diagnostic Criteria	Obesity Diagnostic Criteria		
	BMI ≤30 kg/m <sup>2</sup>	FM >38%	FMI ≤11.8kg/m <sup>2</sup>
	n (%)		
Group I (n=78)			
MMI ≤ 6.61 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MMI ≤ 6.2 kg/m <sup>2</sup> **	0 (0)	0 (0)	0 (0)
MMI ≤ 7.12 kg/m <sup>2</sup> ***	0 (0)	1 (1.3)	0 (0)
SMI ≤ 29.2% *	5 (6.4)	9 (11.5)	5 (6.4)
SMI ≤ 26.6% **	5 (6.4)	9 (11.5)	5 (6.4)
SMI ≤ 33.87% ***	5 (6.4)	9 (11.5)	5 (6.4)
FFMI ≤ 14.59 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MM < 15 kg and hand grip strength < 16 kg ****	0 (0)	0 (0)	0 (0)
ASMI < 6 kg and hand grip strength < 16 kg ****	0 (0)	0 (0)	0 (0)
Group II (n=25)			
MMI ≤ 6.61 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MMI ≤ 6.2 kg/m <sup>2</sup> **	0 (0)	0 (0)	0 (0)
MMI ≤ 7.12 kg/m <sup>2</sup> ***	0 (0)	2 (8)	0 (0)
SMI ≤ 29.2% *	8 (32)	10 (40)	6 (24)
SMI ≤ 26.6% **	8 (32)	9 (36)	6 (24)
SMI ≤ 33.87% ***	8 (32)	10 (40)	6 (24)
FFMI ≤ 14.59 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MM < 15 kg and hand grip strength < 16 kg ****	0 (0)	1 (4)	0 (0)
ASMI < 6 kg and hand grip strength < 16 kg ****	0 (0)	0 (0)	0 (0)
Group III (n=73)			
MMI ≤ 6.61 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MMI ≤ 6.2 kg/m <sup>2</sup> **	0 (0)	0 (0)	0 (0)
MMI ≤ 7.12 kg/m <sup>2</sup> ***	0 (0)	0 (0)	0 (0)
SMI ≤ 29.2% *	1 (1.4)	3 (4.1)	1 (1.4)
SMI ≤ 26.6% **	1 (1.4)	3 (4.1)	1 (1.4)
SMI ≤ 33.87% ***	1 (1.4)	3 (4.1)	1 (1.4)
FFMI ≤ 14.59 kg/m <sup>2</sup> *	0 (0)	0 (0)	0 (0)
MM < 15 kg and hand grip strength < 16 kg ****	0 (0)	1 (1.4)	0 (0)
ASMI < 6 kg and hand grip strength < 16 kg ****	0 (0)	0 (0)	0 (0)

**Notes:** \*With reference to cut-off points according to Milewska,<sup>30</sup> \*\*With reference to cut-off points according to Tichet,<sup>43</sup> \*\*\*With reference to cut-off points according to Siemaszko,<sup>24</sup> \*\*\*\*With reference to cut-off points according to EWGSOP2.<sup>13</sup>

**Abbreviations:** BMI, body mass index; FMI, fat mass index; MMI, muscle mass index; SMI, skeletal muscle index; FFMI, fat-free mass index.

may be corroborated by the study by Milewska et al<sup>30</sup> and Tichet et al.<sup>43</sup> The index prevents the underestimation of sarcopenia occurrence in persons with body weight beyond the reference values. Due to the fact that despite a relatively stable body weight the amount of adipose tissue increases in

relation to muscle tissue in elderly people, the diagnosis of SO should be based on several indices.

Regardless of the adopted criterion for diagnosing obesity, the identification of SO with FFMI revealed the lowest percentage of SO cases in all groups. However, the difference was not statistically significant. Siemaszko et al and Milewska et al noted that using this index may be useful in diagnosing SO in individuals with normal and excessive body weight.<sup>24,25,30</sup> Similar results were obtained when MMI and ASMI were combined with the index of hand grip strength.

A similar study was conducted by Milewska et al in a group of healthy women.<sup>30</sup> Similar to the present study, the highest percentage of individuals with SO was identified with the use of SMI, regardless of the adopted cut-off value. SO diagnosed with the FFMI index led to the lowest detectability of SO, which was similar to our observations.

The obtained results cannot be compared to the results of other researchers because no publication tackling the issue of sarcopenic obesity in women with breast cancer was found.

Several studies assessing the correlation between SO and tumors other than breast cancer were conducted in the past few years. It has not been fully elucidated why some of them revealed a correlation between SO and neoplastic diseases<sup>5,8,48,35,39</sup> while others did not.<sup>14,15,38</sup> It may be assumed that it is usually due to a small size of the study group in which SO patients constitute a relatively low percentage. SO development is associated with the ageing process of the body and the reduction of physical activity and sedentary lifestyle. As regards oncological patients, SO is additionally associated with muscle mass loss resultant from the course of the disease.<sup>28,36</sup> At the same time, in the case of some tumors the tendency towards adipose tissue increase is observed, while the muscle mass is reduced.<sup>36</sup> Muscle loss may also be associated with the kind of treatment and administered drugs, persistent inflammation and the catabolic specificity of tumors.<sup>20</sup> Patients frequently manifest reduced energy requirement and the implemented treatment often contributes to decreased physical activity and appetite.<sup>18</sup> The results of a pilot study by Demark-Wahnefried et al suggested that dietetic interventions and the introduction of physical exercise programs may prove effective in preventing unfavorable changes in body weight and composition in women receiving adjuvant chemotherapy in the treatment of breast cancer.<sup>17</sup>

The results of numerous studies indicated the necessity of the implementation of body composition assessment in

planning the oncological care, including dietetic and physiotherapeutic interventions.<sup>16,21,23</sup> It is noteworthy that body composition assessment is simple and may be relatively easily introduced in the routine care of oncological patients. It facilitates the diagnostics of sarcopenia and sarcopenic obesity. However, the precise assessment of the influence of body composition on the effectiveness of oncological treatment requires further research, preferably in the form of prospective clinical studies.<sup>6,45</sup>

Undoubtedly, small sample size is a limitation of the present study, especially as regards patients with tumor recurrence. The discussion of the problem of SO diagnostics is additionally impeded by the inability to assess the third parameter included in the definition of sarcopenia – physical fitness, and the diversification of outcomes resulting from the necessity to select several options of cut-off values and definitions. It is also difficult to disregard the significance of the difference in the age of the patients in the interpretation of the results. Another limitation of the study is not taking into consideration the role of drugs used by these patients that are not limited to the anticancer treatment, eg, denosumab, also indicated for the prevention of osteoporosis in aromatase inhibitors treated women, has been suggested to modulate insulin resistance and possibly rising metabolic concerns. The lack of data on comorbidity is also a limitation of the study.

## Conclusions

Sarcopenia was more common in women with the recurrence of breast cancer than in women in remission and in women with no history of breast cancer. However, this observation requires further study involving a larger group of women. The highest SO detectability was obtained with the use of the skeletal muscle index (SMI), regardless of the adopted cut-off value and the criterion for diagnosing obesity. However, it needs to be emphasized that no statistical significance was noted in the case of any of the observed differences in diagnosing SO with the use of various pairs of diagnostic criteria.

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Declaration of Helsinki. The manuscript has not been published previously, it is not under consideration for publication elsewhere, its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

## Disclosure

The authors report no conflicts of interest in this work.

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